

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 11-092102

(43)Date of publication of application : 06.04.1999

(51)Int.Cl.

C01B 3/38

H01M 8/06

(21)Application number : 10-210354

(71)Applicant : TOYOTA MOTOR CORP

(22)Date of filing : 08.07.1998

(72)Inventor : MIZUNO SEIJI
OZAKI TOSHIAKI
KAWAHARA TATSUYA
TAKI MASAYOSHI
KINOSHITA KATSUHIKO
NEGISHI YOSHIMASA

(30)Priority

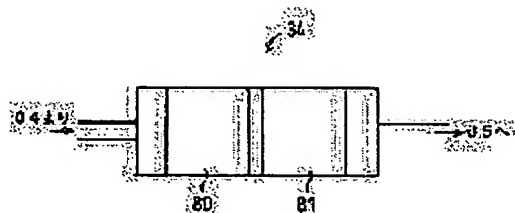
Priority number : 09214112 Priority date : 23.07.1997 Priority country : JP

(54) REFORMING DEVICE OF FUEL

(57)Abstract:

PROBLEM TO BE SOLVED: To make the inner temp. of a fuel cell device uniform in a specified temp. range.

SOLUTION: A source fuel gas containing air is supplied from a second fuel supply passage 64 to a reforming device 34 equipped with a Cu-Zn catalyst, the reforming reaction with water vapor and the oxidation reaction proceed inside the device, and the produced hydrogen-rich fuel gas is discharged to a third fuel supply passage 65. The reforming device 34 consists of a reaction part 80 in the upstream side and a reaction part 81 in the downstream side. Both of the reaction parts 80, 81 consists of a honeycomb structure in such a manner that the sum of the cross section of the passage in each reaction part, namely, the sum of the cross-sectional area of cells which constitute the respective honeycomb structures is smaller in the reaction part 80 in the upstream side. Therefore, the flow rate of the gas passing through the reforming device 34 is higher in the upstream side than in the downstream side.



LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] A reaction accompanied by an endothermic characterized by providing the following A steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam The catalyst section which is a reaction accompanied by pyrexia, is the fuel reformer which uses heat produced in said oxidation reaction in case oxidation reaction which oxidizes said hydrocarbon is gone on and said steam-reforming reaction is gone on, and is equipped with a catalyst which promotes said steam-reforming reaction and said oxidation reaction A original fuel gas supply means to supply original fuel gas containing said hydrocarbon, steam, and oxygen to said catalyst section the hydrogen which produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- the gas flow rate accommodation means which makes quick the rate of flow of said Hara fuel gas in the portion of the side into which said Hara fuel gas is introduced so that a fuel-gas discharge means discharge rich fuel gas from said catalyst section, and the heat which arose in said oxidation reaction which occurs in said catalyst section in a portion of a side to which said Hara fuel gas is supplied may fully be carried to the downstream

[Claim 2] Said gas flow rate accommodation means is a fuel reformer according to claim 1 which comes it smaller than a side by which said fuel gas is discharged at a side to which said Hara fuel gas in said catalyst section is supplied to carry out a gross area of a cross section of passage where said Hara fuel gas flows.

[Claim 3] A steam-reforming reaction which is a reaction accompanied by an endothermic and generates hydrogen from a hydrocarbon and a steam, Oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with a catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply original fuel gas containing said hydrocarbon, steam, and oxygen to said catalyst section, hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- a fuel reformer held at catalyst support in which is equipped with a fuel gas discharge means to discharge rich fuel gas from said catalyst section, and said catalyst in said catalyst section is formed with a thermally conductive, comparatively high material.

[Claim 4] Claim 1 thru/or a catalyst which it is the fuel reformer of a publication 3 either, and said hydrocarbon is a methanol, and promotes said steam-reforming reaction and said oxidation reaction are a fuel reformer which is a single copper system catalyst.

[Claim 5] A reaction accompanied by an endothermic characterized by providing the following A steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam The catalyst section which is a reaction accompanied by pyrexia, is the fuel reformer which uses heat produced in said oxidation reaction in case oxidation reaction which oxidizes said hydrocarbon is gone on and said steam-reforming reaction is gone on, and is equipped with a catalyst which promotes said steam-reforming reaction, and a catalyst which promotes said oxidation reaction A original fuel gas supply means to supply original fuel gas containing said hydrocarbon and steam to said catalyst section the hydrogen produced as a result of an oxidation gas-supply means supply oxidation gas containing oxygen to said catalyst section, said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- a fuel-gas discharge means discharge rich fuel gas from said catalyst section, and an oxidation-reaction control means control advance of said oxidation reaction to a side into which said oxidation gas in said catalyst section is introduced [Claim 6] For a direction of a side into which said oxidation gas is introduced [in / are a fuel reformer according to claim 5, and / said catalyst section], said oxidation reaction control means is a fuel reformer in which it forms and which it becomes as an amount of a catalyst for which said oxidation reaction is promoted rather than a side by which said fuel gas is discharged serves as smallness.

[Claim 7] For a direction of a side into which it is the same catalyst and said oxidation gas is introduced, said oxidation reaction control means is [a catalyst which is a fuel reformer according to claim 6, and promotes said steam-reforming

reaction, and a catalyst which promotes said oxidation reaction] a fuel reformer which forms and becomes so that an amount of said catalyst may serve as smallness from a side by which said fuel gas is discharged.

[Claim 8] A steam-reforming reaction which is a reaction accompanied by an endothermic and generates hydrogen from a hydrocarbon and a steam, Oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with a catalyst which promotes said steam-reforming reaction, and a catalyst which promotes said oxidation reaction, A original fuel gas supply means to supply original fuel gas containing said hydrocarbon and steam to said catalyst section, An oxidation gas supply means to supply oxidation gas containing oxygen to said catalyst section, hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- rich fuel gas with a fuel gas discharge means to discharge from said catalyst section It has a reaction condition detection means to detect an advance condition of a reaction which advances in said catalyst department. Said oxidation gas supply means A fuel reformer further equipped with an oxygen density accommodation means to control an oxygen density in said oxidation gas supplied to said catalyst section based on an advance condition of said reaction which said reaction condition detection means detected, maintaining the amount of oxygen per [which is supplied to said catalyst section] unit time amount in a desired amount.

[Claim 9] It is the fuel reformer to which it is a fuel reformer according to claim 8, said catalyst section becomes from two or more reaction sections equipped with said catalyst, and said oxidation gas supply means supplies said oxidation gas to each of two or more of said reaction sections.

[Claim 10] A catalyst which is the fuel reformer of a publication 9 either and promotes claim 5 thru/or a catalyst which said hydrocarbon is a methanol and promotes said steam-reforming reaction and said oxidation reaction is a fuel reformer which is the same copper system catalyst.

[Claim 11] A steam-reforming reaction which is a reaction accompanied by an endothermic and generates hydrogen from a hydrocarbon and a steam, Oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with a catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply original fuel gas containing said hydrocarbon, steam, and oxygen to said catalyst section, In a fuel gas discharge means to discharge rich fuel gas from said catalyst section, and said catalyst section hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- A fuel reformer equipped with a direction modification means of gas supply to replace a part introduced in said Hara fuel gas from said Hara fuel gas supply means, and a part which discharges said fuel gas with said fuel gas discharge means, and to reverse a flow of gas in said catalyst section.

[Claim 12] It has further an edge temperature detection means to be a fuel reformer according to claim 11, and to detect temperature of a near predetermined location to which said Hara fuel gas is supplied from said Hara fuel gas supply means in said catalyst section. Said direction modification means of gas supply is a fuel reformer which replaces a part introduced in said Hara fuel gas from said Hara fuel gas supply means, and a part which discharges said fuel gas with said fuel gas discharge means based on a detection result of said edge temperature detection means.

[Claim 13] A reaction accompanied by an endothermic characterized by providing the following A steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam The catalyst section which is a reaction accompanied by pyrexia, is the fuel reformer which uses heat produced in said oxidation reaction in case oxidation reaction which oxidizes said hydrocarbon is gone on and said steam-reforming reaction is gone on, and comes to enclose with the interior a particle equipped with a catalyst which promotes said steam-reforming reaction and said oxidation reaction A original fuel gas supply means to supply original fuel gas containing said hydrocarbon, steam, and oxygen to said catalyst section hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- a fuel gas discharge means to discharge rich fuel gas from said catalyst section, and a catalyst churning means to agitate a particle equipped with said catalyst in said catalyst department

[Claim 14] It is the fuel reformer which agitates a particle which is a fuel reformer according to claim 13, said Hara fuel gas supply means is equipped with said catalyst churning means, sprays gas containing at least one of said hydrocarbons, steams, and oxygen on said catalyst circles, and is equipped with said catalyst in said catalyst department.

[Claim 15] A reaction accompanied by an endothermic characterized by providing the following A steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam The catalyst section which is a reaction accompanied by pyrexia, is the fuel reformer which uses heat produced in said oxidation reaction in case oxidation

reaction which oxidizes said hydrocarbon is gone on and said steam-reforming reaction is gone on, and is equipped with a catalyst which promotes said steam-reforming reaction and said oxidation reaction A original fuel gas supply means to supply original fuel gas containing said hydrocarbon and steam to said catalyst section the hydrogen which produced as a result of an oxidation gas-supply means supply oxidation gas containing oxygen to said catalyst section, said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- a fuel-gas discharge means discharge rich fuel gas from said catalyst section, and a supply part modification means change with time the part to which said oxidation gas is supplied from said oxidation gas-supply means in said catalyst section

[Claim 16] A steam-reforming reaction which is a reaction accompanied by an endothermic and generates hydrogen from a hydrocarbon and a steam, Oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with a catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply original fuel gas containing said hydrocarbon and steam to said catalyst section, An oxidation gas supply means to supply oxidation gas containing oxygen to said catalyst section, In a fuel gas discharge means to discharge rich fuel gas from said catalyst section, and said catalyst section hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- A fuel reformer equipped with a soak-ized means to adjoin a discharge side by which said fuel gas is discharged a supply side to which oxidation gas is supplied with said Hara fuel gas, and to make heat exchange perform between said supply side and said discharge side.

[Claim 17] It is the fuel reformer which said catalyst section equips the interior with said catalyst respectively, and has at least two or more reaction sections which are fuel reformers according to claim 16, and have mutually said each [of said supply], and discharge side in a location of reverse, adjoins said discharge side of said feed zone of said supply side of one of said reaction section, and another side in said two or more reaction sections, and comes to prepare.

[Claim 18] Said catalyst section is a fuel reformer according to claim 16 which has the clinch section in passage of said Hara fuel gas formed in the interior, adjoins and comes to prepare the entry section and the outlet section of said passage.

[Claim 19] A reaction accompanied by an endothermic characterized by providing the following A steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam The catalyst section which is a reaction accompanied by pyrexia, is the fuel reformer which uses heat produced in said oxidation reaction in case oxidation reaction which oxidizes said hydrocarbon is gone on and said steam-reforming reaction is gone on, and is equipped with a catalyst which promotes said steam-reforming reaction and said oxidation reaction A original fuel gas supply means to supply original fuel gas containing said hydrocarbon and steam to said catalyst section the hydrogen which produced as a result of an oxidation gas-supply means supply the oxidation gas containing oxygen to said catalyst section, said steam-reforming reaction which advance in said catalyst section, and said oxidation reaction -- the heating means heat portions other than the side to which said oxidation gas is supplied with the predetermined fluid which conducts a fuel-gas discharge means discharge rich fuel gas from said catalyst section, and the heat which produce in the predetermined member which constitutes a system equipped with said fuel reformer

[Claim 20] Said heating means is a fuel reformer according to claim 19 which heats portions other than a side to which said oxidation gas is supplied by elevated-temperature gas discharged from a predetermined member which constitutes a system equipped with said fuel reformer.

[Claim 21] A reaction accompanied by an endothermic characterized by providing the following A steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam The catalyst section which is a reaction accompanied by pyrexia, is the fuel reformer which uses heat produced in said oxidation reaction in case oxidation reaction which oxidizes said hydrocarbon is gone on and said steam-reforming reaction is gone on, and is equipped with a catalyst which promotes said steam-reforming reaction and said oxidation reaction A original fuel gas supply means to supply original fuel gas containing said hydrocarbon and steam to said catalyst section the hydrogen which produced as a result of an oxidation gas-supply means supply oxidation gas containing oxygen to said catalyst section, said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- an edge cooling means spray the liquid which serves as a fuel-gas discharge means discharge rich fuel gas from said catalyst section, at least from one side among said hydrocarbon and water to the portion of the side supplied to said Hara fuel gas and said oxidation gas

[Claim 22] Claim 11 thru/or a catalyst which it is the fuel reformer of a publication 21 either, and said hydrocarbon is a methanol, and promotes said steam-reforming reaction and said oxidation reaction are a fuel reformer which is a single copper system catalyst.

[Claim 23] A steam-reforming reaction which is a reaction accompanied by an endothermic and generates hydrogen from a hydrocarbon and a steam, Oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said

hydrocarbon is gone on. The 1st reaction section equipped with a catalyst which is the fuel reformer which uses heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and promotes said steam-reforming reaction and said oxidation reaction, The catalyst section equipped with the 2nd reaction section equipped with a catalyst which promotes said steam-reforming reaction, A original fuel gas supply means to supply original fuel gas containing said hydrocarbon and steam to said catalyst section, An oxidation gas supply means to supply oxidation gas containing oxygen to said 1st reaction section, It has a fuel gas discharge means to discharge rich fuel gas from said catalyst section. hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- said catalyst section A fuel reformer to which said 1st reaction section and said 2nd reaction section are made to adjoin, and heat exchange is made to perform between said 1st reaction section and said 2nd reaction section.

[Claim 24] A catalyst with which it is a fuel reformer according to claim 23, said hydrocarbon is a methanol, and said 1st reaction section is equipped is a fuel reformer which is a single copper system catalyst.

[Claim 25] It is the fuel reformer which is equipped with the following and characterized by said catalyst promoting a reaction which does not go via a reaction path which generates a carbon monoxide as said oxidation reaction. A steam-reforming reaction which is a reaction accompanied by an endothermic and generates hydrogen from a hydrocarbon and a steam The catalyst section which is a reaction accompanied by pyrexia, is the fuel reformer which uses heat produced in said oxidation reaction in case oxidation reaction which oxidizes said hydrocarbon is gone on and said steam-reforming reaction is gone on, and is equipped with a catalyst which promotes said steam-reforming reaction and said oxidation reaction A original fuel gas supply means to supply original fuel gas containing said hydrocarbon, steam, and oxygen to said catalyst section hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- a fuel gas discharge means to discharge rich fuel gas from said catalyst section

[Claim 26] A catalyst which it is a fuel reformer according to claim 25, and said hydrocarbon is a methanol, and promotes said steam-reforming reaction and said oxidation reaction is a fuel reformer which is a single copper system catalyst.

[Translation done.]

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] This invention relates to the fuel reformer which generates hydeogen-rich gas from a hydrocarbon and a steam in detail about a fuel reformer.

[0002]

[Description of the Prior Art] The fuel reformer which generates hydeogen-rich gas from a hydrocarbon and a steam is known as equipment for supplying fuel gas to a fuel cell. A fuel cell is equipment which changes into direct electrical energy the chemical energy which a fuel has, without going via mechanical energy or heat energy, and can realize high energy efficiency. The fuel gas containing hydrogen is supplied to such a fuel cell at a cathode side, and the oxidation gas containing oxygen is supplied to it at an anode plate side, and it acquires electromotive force according to the electrochemical reaction which occurs on two poles. The formula showing the electrochemical reaction which occurs in below with a fuel cell is shown. (1) A formula expresses the reaction by the side of cathode, and the reaction by the side of an anode plate of (2) types, and the reaction shown in (3) types advances in the whole fuel cell.

[0003]

$H_2 \rightarrow 2H^{++} + 2e^-$ -- (1)

$(1/2) O_2 + 2H^{++} + 2e^- \rightarrow H_2O$ -- (2)

$H_2 + (1/2) O_2 \rightarrow H_2O$ -- (3)

[0004] It is possible to use the oxidation gas containing a carbon dioxide and fuel gas from the property of the electrolyte among various fuel cells with a polymer electrolyte fuel cell, a phosphoric acid fuel cell, and a melting carbonate electrolyte mold fuel cell. Then, with these fuel cells, the hydeogen-rich gas which carried out steam reforming of the hydrocarbons, such as a methanol and natural gas, and generated them is usually used as fuel gas, using air as oxidation gas. Therefore, the above-mentioned fuel reformer is prepared in the fuel cell system equipped with such a fuel cell, a steam-reforming reaction is performed in this fuel reformer, and fuel gas is generated. Below, the reforming reaction which advances inside a fuel reformer is explained. Here, the case where a methanol is used as a hydrocarbon with which a reforming reaction is presented is explained. The formula showing the reaction which carries out steam reforming of the methanol to below is shown.

[0005]

$CH_3OH + H_2O \rightarrow CO_2 + 3H_2 - 49.5 \text{ (kJ/mol)}$ -- (4)

[0006] As shown in the above-mentioned (4) formula, since a steam-reforming reaction is endothermic reaction, in order to advance a reforming reaction, it needs to supply heat energy. The method of forming a burner, a heater, etc. in a fuel reformer and performing heat tracing as a method of supplying the heat energy which a reforming reaction takes, the method of advancing a steam-reforming reaction using the heat which is made to perform the oxidation reaction which is exothermic reaction in addition to a steam-reforming reaction, and is produced in oxidation reaction in the interior of a fuel reformer, etc. are learned. Among these methods, how to advance oxidation reaction with a steam-reforming reaction inside a fuel reformer is explained.

[0007]

$CH_3OH + (1/2) O_2 \rightarrow CO_2 + 2H_2 + 189.5 \text{ (kJ/mol)}$ -- (5)

[0008] The above-mentioned (5) formula expresses an example (partial oxidation reaction) of oxidation reaction of a methanol. Oxygen is supplied to the fuel reformer which performs a steam-reforming reaction, and if a methanol is made to oxidize with the steam-reforming reaction expressed to (4) types, the heat energy produced in oxidation reaction can be used in a steam-reforming reaction. If the amount of oxygen supplied to a fuel reformer is adjusted here, the quantity of heat which a steam-reforming reaction takes, and the quantity of heat produced in oxidation reaction can

be balanced, and it will also become possible to provide meals with the quantity of heat which produces theoretically all the quantity of heat that a steam-reforming reaction takes in oxidation reaction. The method of providing with the quantity of heat which produces the quantity of heat which such a steam-reforming reaction takes in oxidation reaction can reduce the amount of energy lost by thermolysis compared with the method of performing heat tracing mentioned already, and can realize higher energy efficiency. Furthermore, compared with the method of performing heat tracing, the configuration of a fuel reformer can be simplified and the whole system can be miniaturized.

[0009]

[Problem(s) to be Solved by the Invention] However, the above-mentioned method of using the heat energy which supplied oxygen with the methanol and the steam to the fuel reformer, and was produced by oxidation reaction at a steam-reforming reaction had the problem that the distribution condition of temperature will become an ununiformity, in the interior of a fuel reformer. Drawing 38 is explanatory drawing showing the situation of the temperature distribution in the interior of a fuel reformer when supplying oxygen to a fuel reformer with a methanol and a steam, and oxidizing with a steam-reforming reaction. If oxygen is introduced with a methanol and a steam to a fuel reformer, since the reaction rate of oxidation reaction is quicker than a steam-reforming reaction, as the quantity of heat produced in oxidation reaction exceeds the quantity of heat which a steam reaction takes and it is shown in drawing 38, by the upstream (side which introduces the gas containing a methanol, a steam, and oxygen) in a fuel reformer, internal temperature will rise rapidly and the peak of temperature distribution will be formed. Moreover, in order only for a steam-reforming reaction to advance after oxygen is consumed by oxidation reaction, as for after the peak of the above-mentioned temperature distribution, the internal temperature of a fuel reformer continues descent toward the downstream (side by which hydeogen-rich gas is discharged).

[0010] When temperature distribution form a peak inside a fuel reformer and temperature rises too much, a catalyst deteriorates or problems, like a by-product arises are produced. First, deterioration of a catalyst is explained. For example, in using a Cu-Zn catalyst as a catalyst which promotes the steam-reforming reaction and oxidation reaction of a methanol, when it uses this Cu-Zn catalyst under the elevated temperature exceeding 300 degrees C, the endurance of a catalyst falls and there is a possibility of causing and carrying out sintering. Sintering means the phenomenon which the catalyst supported by the carrier surface condenses here. Although the Cu-Zn catalyst is usually carrying out the configuration to which copper particles are scattered on the surface of a zinc particle, if sintering is caused, a copper particle will condense and a particle will grow large. If such a phenomenon arises, since the activity area of a catalyst decreases with the fall of the surface area of a copper particle, the engine performance of a fuel reformer will fall.

[0011] Moreover, reactions other than the normal reaction for which generating of the by-product which is another problem by whenever [catalyst temperature] going up too much mentioned already when a reforming reaction advanced under a predetermined elevated temperature occur, and it says that methane arises, or the nitrogen gas in the supplied pressurization air reacts, and nitrogen oxides arise. In the range of the reforming reaction temperature in a fuel reformer, it is not decomposed and these by-products will be supplied to a fuel cell as fuel gas as they are. Especially the thing that the amounts of generation, such as methane, increase leads to the fall of the hydrogen partial pressure in fuel gas and is not desirable.

[0012] On the other hand, if internal temperature falls in the downstream of a fuel reformer, the problem that the activity of a steam-reforming reaction falls with the fall of temperature will be produced. When the activity of a steam-reforming reaction falls, there is gas which has not completed a reforming reaction, i.e., a possibility that a methanol may remain and gas with inadequate hydrogen concentration may be generated. Or even if internal temperature falls by the downstream, it is necessary to have a fuel reformer big enough so that a reforming reaction may be completed.

[0013] The fuel reformer of this invention solved such a problem, was made for the purpose of equalizing the internal temperature of a fuel reformer in a predetermined temperature requirement, and took the next configuration.

[0014]

[The means for solving a technical problem, and its operation and effect] The steam-reforming reaction which the 1st fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon, steam, and oxygen to said catalyst section, In a fuel gas discharge means to discharge rich fuel gas from said catalyst section, and said catalyst section the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- Let it be a summary to have the gas flow rate accommodation means which makes quick the rate of flow of said Hara fuel gas in the portion of the side into

which said Hara fuel gas is introduced so that the heat produced in said oxidation reaction which occurs in the portion of the side to which said Hara fuel gas is supplied may fully be carried to the downstream.

[0015] If the original fuel gas containing a hydrocarbon, a steam, and oxygen is supplied to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, in this catalyst section, the 1st fuel reformer of this invention constituted as mentioned above will be a reaction accompanied by an endothermic, and will advance the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon. the heat produced in said oxidation reaction at this time -- using -- said steam-reforming reaction -- going on -- hydrogen -- rich fuel gas is generated and it is discharged from said catalyst section. Here, in the catalyst section, the rate of flow of said Hara fuel gas in the portion of the side into which said Hara fuel gas is introduced is adjusted so that the heat produced in said oxidation reaction which occurs in the portion of the side to which said Hara fuel gas is supplied may fully be carried to the downstream.

[0016] Since the heat produced by the oxidation reaction which occurs in the portion of the side into which said Hara fuel gas is introduced is fully carried to the downstream according to such a fuel reformer, in the portion of the side into which said Hara fuel gas is introduced, temperature does not rise too much. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly. Furthermore, by fully carrying the heat produced in oxidation reaction to the downstream, in the downstream, activity of a steam-reforming reaction can be made high enough, and it becomes possible to miniaturize a fuel reformer.

[0017] After the hydrocarbon, the steam, and oxygen which constitute original fuel gas mix all beforehand, it is not necessary to supply them here, and a part of at least one component or original fuel gas is good also as supplying separately. Even if it does not mix beforehand, the effect described above when these components that constitute original fuel gas were supplied from the upstream of the flow direction of the gas in the catalyst section can be acquired. Moreover, the catalyst which promotes a steam-reforming reaction, and the catalyst which promotes oxidation reaction may be the same, and you may differ. That is, a steam-reforming reaction and oxidation reaction are good also as both reactions being promoted by the single catalyst, and it is good also as each reaction being promoted by different catalyst. When using a different catalyst, it is desirable to fully mix both within a reforming machine.

[0018] In the 1st fuel reformer of above-mentioned this invention, said gas flow rate accommodation means is better than the side by which said fuel gas is discharged at the side to which said Hara fuel gas in said catalyst section is supplied also as coming it small to carry out the gross area of the cross section of the passage where said Hara fuel gas flows. By considering as such a configuration, the rate of flow of said Hara fuel gas in that of the side to which said Hara fuel gas is supplied can be made quicker than the side by which said fuel gas is discharged, and the above-mentioned effect can be acquired.

[0019] The steam-reforming reaction which the 2nd fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon, steam, and oxygen to said catalyst section, the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- rich fuel gas Having a fuel gas discharge means to discharge from said catalyst section, said catalyst in said catalyst section makes it a summary to be held at the catalyst support formed with a thermally conductive, comparatively high material.

[0020] The 2nd fuel reformer of this invention constituted as mentioned above If the original fuel gas containing a hydrocarbon, a steam, and oxygen is supplied to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, it will set in this catalyst section. the hydrogen which advanced and generated the steam-reforming reaction which is a reaction accompanied by an endothermic and generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon -- rich fuel gas is discharged. Here, since said catalyst is supported by the catalyst support formed with a thermally conductive, comparatively high material, the heat produced in said oxidation reaction is promptly told to a periphery by catalyst support, and is used for said steam-reforming reaction.

[0021] Since the heat produced in oxidation reaction is spread promptly according to such a fuel reformer, it is the side to which said Hara fuel gas is supplied, and temperature does not rise too much to the side to which said oxidation reaction advances actively. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised

greatly. Furthermore, by spreading the heat produced in oxidation reaction and being told to the downstream, in the downstream, activity of a steam-reforming reaction can be made high enough, and it becomes possible to miniaturize a fuel reformer.

[0022] The steam-reforming reaction which the 3rd fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction, and the catalyst which promotes said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon and steam to said catalyst section, An oxidation gas supply means to supply the oxidation gas containing oxygen to said catalyst section, In the side into which a fuel gas discharge means to discharge rich fuel gas from said catalyst section, and said oxidation gas in said catalyst section are introduced the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- Let it be a summary to have an oxidation reaction control means to control advance of said oxidation reaction.

[0023] If the original fuel gas containing a hydrocarbon and a steam and the oxidation gas containing oxygen supply to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, the 3rd fuel reformer of this invention constituted as mentioned above is a reaction accompanied by an endothermic, and will advance the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon in this catalyst section. the heat produced in said oxidation reaction at this time -- using -- said steam-reforming reaction -- going on -- hydrogen -- rich fuel gas is generated and it is discharged from said catalyst section. Here, in the catalyst section, advance of said oxidation reaction is controlled at the side into which said oxidation gas is introduced.

[0024] Since advance of said oxidation reaction is controlled at the side into which said oxidation gas is introduced according to such a fuel reformer, temperature does not rise too much to the side into which said this oxidation gas is introduced. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly. Furthermore, by controlling advance of oxidation reaction by the side into which said oxidation gas is introduced, the field where oxidation reaction advances raises the temperature of the downstream by breadth and this to the downstream more, and can make activity of a steam-reforming reaction high enough. Therefore, it becomes possible to miniaturize a fuel reformer.

[0025] In the 3rd fuel reformer of above-mentioned this invention, said oxidation reaction control means is good in said catalyst section also as forming and becoming so that the amount of the catalyst for which the side into which said oxidation gas is introduced promotes said oxidation reaction rather than the side by which said fuel gas is discharged may serve as smallness.

[0026] Moreover, in the 3rd fuel reformer of this invention, the catalyst which promotes said steam-reforming reaction, and the catalyst which promotes said oxidation reaction are the same catalysts, and said oxidation reaction control means is good also as forming and consisting of a side by which said fuel gas is discharged for the direction of the side into which said oxidation gas is introduced so that the amount of said catalyst may serve as smallness.

[0027] The steam-reforming reaction which the 4th fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction, and the catalyst which promotes said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon and steam to said catalyst section, An oxidation gas supply means to supply the oxidation gas containing oxygen to said catalyst section, the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- rich fuel gas with a fuel gas discharge means to discharge from said catalyst section It has a reaction condition detection means to detect the advance condition of the reaction which advances in said catalyst department. Said oxidation gas supply means Let it be a summary to have further an oxygen density accommodation means to control the oxygen density in said oxidation gas supplied to said catalyst section, based on the advance condition of said reaction which said reaction condition detection means detected, maintaining the amount of oxygen per [which is supplied to said catalyst section] unit time amount in a desired amount.

[0028] If the original fuel gas containing a hydrocarbon and a steam and the oxidation gas containing oxygen supply to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, the

4th fuel reformer of this invention constituted as mentioned above is a reaction accompanied by an endothermic, and will advance the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon in this catalyst section. the heat produced in said oxidation reaction at this time -- using -- said steam-reforming reaction -- going on -- hydrogen -- rich fuel gas is generated and it is discharged from said catalyst section. Here, the advance condition of the reaction which advances in said catalyst department is detected, and based on the advance condition of said this detected reaction, the oxygen density in said oxidation gas supplied to said catalyst section is controlled, maintaining the amount of oxygen per [which is supplied to said catalyst section] unit time amount in a desired amount.

[0029] According to such a fuel reformer, since the oxygen density in said oxidation gas is controlled, the reaction rate of the oxidation reaction which advances to the side into which oxidation gas is introduced can be controlled, and it can prevent that temperature rises too much to the side into which said this oxidation gas is introduced. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly. Furthermore, by controlling the oxygen density in oxidation gas and controlling the reaction rate of oxidation reaction, the field where oxidation reaction advances can be extended more to the downstream, by this, the temperature of the downstream is raised and activity of a steam-reforming reaction can be made high enough. Therefore, it becomes possible to miniaturize a fuel reformer.

[0030] In the 4th fuel reformer of above-mentioned this invention, said catalyst section consists of two or more reaction sections equipped with said catalyst, and said oxidation gas supply means is good also as supplying said oxidation gas to each of two or more of said reaction sections. The effect which equalizes the temperature inside the catalyst section can be further heightened by making into plurality such a configuration, then the part to which oxidation gas is supplied.

[0031] The steam-reforming reaction which the 5th fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon, steam, and oxygen to said catalyst section, In a fuel gas discharge means to discharge rich fuel gas from said catalyst section, and said catalyst section the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- The part introduced in said Hara fuel gas from said Hara fuel gas supply means and the part which discharges said fuel gas with said fuel gas discharge means are replaced, and let it be a summary to have a direction modification means of gas supply to reverse the flow of the gas in said catalyst section.

[0032] If the original fuel gas containing a hydrocarbon, a steam, and oxygen is supplied to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, in this catalyst section, the 5th fuel reformer of this invention constituted as mentioned above will be a reaction accompanied by an endothermic, and will advance the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon. the heat produced in said oxidation reaction at this time -- using -- said steam-reforming reaction -- going on -- hydrogen -- rich fuel gas is generated and it is discharged from said catalyst section. In case such a reaction advances, in said catalyst section, the exchange with the part introduced in said Hara fuel gas and the part which discharges said fuel gas is performed.

[0033] Since the exchange with the part introduced in said Hara fuel gas and the part which discharges said fuel gas is performed in said catalyst section according to such a fuel reformer, in the specific field to which original fuel gas is introduced, temperature does not rise too much. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly. Furthermore, temperature cannot fall in the specific downstream and activity of a steam-reforming reaction can be made high enough in the whole catalyst section. Therefore, it becomes possible to miniaturize a fuel reformer.

[0034] In the 5th fuel reformer of above-mentioned this invention, it sets in said catalyst section. It has further an edge temperature detection means to detect the temperature of the near predetermined location to which said Hara fuel gas is supplied from said Hara fuel gas supply means. Said direction modification means of gas supply It is good also as replacing the part introduced in said Hara fuel gas from said Hara fuel gas supply means, and the part which discharges said fuel gas with said fuel gas discharge means based on the detection result of said edge temperature detection means. By considering as such a configuration, it can prevent certainly that temperature rises too much to the side to which original fuel gas is supplied.

[0035] The steam-reforming reaction which the 6th fuel reformer of this invention is a reaction accompanied by an

endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and comes to enclose with the interior a particle equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon, steam, and oxygen to said catalyst section, the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- let it be a summary to have a fuel gas discharge means to discharge rich fuel gas from said catalyst section, and a catalyst churning means to agitate a particle equipped with said catalyst in said catalyst department.

[0036] The 6th fuel reformer of this invention constituted as mentioned above supplies the original fuel gas containing a hydrocarbon, a steam, and oxygen to the catalyst section which comes to fill [the interior] up a particle equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction. Agitating a particle equipped with said catalyst in said catalyst section in that case, it is a reaction accompanied by an endothermic and the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon are gone on. the heat produced in said oxidation reaction at this time -- using -- said steam-reforming reaction -- going on -- hydrogen -- rich fuel gas is generated and it is discharged from said catalyst section.

[0037] In order to agitate a particle equipped with said catalyst in said catalyst section according to such a fuel reformer, the catalyst with which this particle is equipped is concerned with the sequential aforementioned oxidation reaction, and temperature does not rise too much in the specific field to which original fuel gas is introduced. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly. Furthermore, temperature cannot fall in the specific downstream and activity of a steam-reforming reaction can be made high enough in the whole catalyst section. Therefore, it becomes possible to miniaturize a fuel reformer.

[0038] In the 6th fuel reformer of above-mentioned this invention, said catalyst churning means is good also as agitating the particle which said Hara fuel gas supply means is equipped with, and sprays the gas containing at least one of said hydrocarbons, steams, and oxygen on said catalyst circles, and is equipped with said catalyst in said catalyst department. Churning can be operated to coincidence by spraying the gas which constitutes said Hara fuel to such a configuration, then said catalyst section.

[0039] The steam-reforming reaction which the 7th fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon and steam to said catalyst section, An oxidation gas supply means to supply the oxidation gas containing oxygen to said catalyst section, In a fuel gas discharge means to discharge rich fuel gas from said catalyst section, and said catalyst section the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- Let it be a summary to have a supply part modification means to change with time the part to which said oxidation gas is supplied from said oxidation gas supply means.

[0040] If the original fuel gas containing a hydrocarbon and a steam and the oxidation gas containing oxygen supply to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, the 7th fuel reformer of this invention constituted as mentioned above is a reaction accompanied by an endothermic, and will advance the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon in this catalyst section. At this time, the part to which said oxidation gas is supplied is changed with time in said catalyst section. thus, the heat produced in said oxidation reaction which advances using the supplied oxidation gas -- using -- said steam-reforming reaction -- going on -- hydrogen -- rich fuel gas is generated and it is discharged from said catalyst section.

[0041] In order for the part to which said oxidation gas is supplied to make it change with time in said catalyst section according to such a fuel reformer, in the specific field to which oxidation gas is introduced, temperature does not rise too much. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly.

[0042] The steam-reforming reaction which the 8th fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction

accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon and steam to said catalyst section, An oxidation gas supply means to supply the oxidation gas containing oxygen to said catalyst section, In a fuel gas discharge means to discharge rich fuel gas from said catalyst section, and said catalyst section the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- The discharge side by which said fuel gas is discharged the supply side to which oxidation gas is supplied with said Hara fuel gas is adjoined, and let it be a summary to have a soak-ized means to make heat exchange perform between said supply side and said discharge side.

[0043] If the original fuel gas containing a hydrocarbon and a steam and the oxidation gas containing oxygen supply to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, the 8th fuel reformer of this invention constituted as mentioned above is a reaction accompanied by an endothermic, and will advance the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon in this catalyst section. the heat which heat exchange was performed between said supply side and said discharge side, and was produced in said oxidation reaction here since said catalyst section adjoined the discharge side by which said fuel gas is discharged the supply side to which oxidation gas is supplied with said Hara fuel gas and it was formed -- using -- said steam-reforming reaction -- going on -- hydrogen -- rich fuel gas is generated and it is discharged from said catalyst section.

[0044] Since heat exchange is performed between the discharge sides by which said fuel gas is discharged in said catalyst section the supply side to which oxidation gas is supplied with said Hara fuel gas according to such a fuel reformer, in the specific field to which oxidation gas is introduced, temperature does not rise too much. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly. Furthermore, temperature cannot fall in the specific downstream and activity of a steam-reforming reaction can be made high enough in the whole catalyst section. Therefore, it becomes possible to miniaturize a fuel reformer.

[0045] In the 8th fuel reformer of above-mentioned this invention said catalyst section It is good also as equipping the interior with said catalyst respectively, having at least two or more each reaction sections of said supply which have a side and said discharge side in the location of reverse mutually, adjoining said discharge side of said feed zone of said supply side of one of said reaction section, and another side, and coming to prepare said two or more reaction sections.

[0046] Moreover, in the 8th fuel reformer of this invention, said catalyst section is good also as having the clinch section in the passage of said Hara fuel gas formed in the interior, and coming to prepare the entry section and the outlet section of said passage adjacently.

[0047] The steam-reforming reaction which the 9th fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon and steam to said catalyst section, An oxidation gas supply means to supply the oxidation gas containing oxygen to said catalyst section, the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- rich fuel gas with a fuel gas discharge means to discharge from said catalyst section Let it be a summary to have a heating means to heat portions other than the side to which said oxidation gas is supplied with the predetermined fluid which conducts the heat produced in the predetermined member which constitutes a system equipped with said fuel reformer.

[0048] If the original fuel gas containing a hydrocarbon and a steam and the oxidation gas containing oxygen supply to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, the 9th fuel reformer of this invention constituted as mentioned above is a reaction accompanied by an endothermic, and will advance the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon in this catalyst section. Here, in said catalyst section, said steam-reforming reaction advances using the heat produced in said oxidation reaction in the field in which said oxidation gas is supplied and said oxidation reaction is performed. Moreover, the heat produced in the predetermined member which constitutes a system equipped with said fuel reformer from portions other than the side to which said oxidation gas is supplied is conducted by the predetermined fluid, and said steam-reforming reaction

advances using this heat. the generated hydrogen -- rich fuel gas is discharged from said catalyst section.

[0049] According to such a fuel reformer, in portions other than the side to which said oxidation gas is supplied Since said oxidation reaction advances using the heat produced in the predetermined member which constitutes a system equipped with said fuel reformer, The amount of said oxidation gas supplied to said catalyst section can be reduced to the amount of said Hara fuel gas supplied to said catalyst section, and temperature does not rise too much to the side to which said oxidation gas is supplied. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly. Furthermore, since the heat produced in the predetermined member which constitutes a system equipped with said fuel reformer from portions other than the side to which said oxidation gas is supplied is told, when temperature falls, the activity of a steam-reforming reaction does not fall. Therefore, activity of a steam-reforming reaction can be made high enough in the whole catalyst section, and it becomes possible to miniaturize a fuel reformer. Moreover, in order to use the heat produced in the predetermined member which constitutes a system equipped with said fuel reformer, system-wide energy efficiency does not fall by heating portions other than the side to which said oxidation gas is supplied.

[0050] Moreover, in the 9th fuel reformer of above-mentioned this invention, said heating means is good also as heating portions other than the side to which said oxidation gas is supplied by the elevated-temperature gas discharged from the predetermined member which constitutes a system equipped with said fuel reformer.

[0051] The steam-reforming reaction which the 10th fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon and steam to said catalyst section, An oxidation gas supply means to supply the oxidation gas containing oxygen to said catalyst section, the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- rich fuel gas with a fuel gas discharge means to discharge from said catalyst section Let it be a summary to have an edge cooling means to spray the liquid which consists at least of one side among said hydrocarbon and water to the portion of the side supplied to said Hara fuel gas and said oxidation gas.

[0052] If the original fuel gas containing a hydrocarbon and a steam and the oxidation gas containing oxygen supply to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, the 10th fuel reformer of this invention constituted as mentioned above is a reaction accompanied by an endothermic, and will advance the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon in this catalyst section. Although said steam-reforming reaction advances using the heat produced in said oxidation reaction in the field in which said oxidation gas is supplied and said oxidation reaction is performed in said catalyst section here, the portion to which the fuel spray of the liquid which consists at least of one side among said hydrocarbon and water was carried out to the portion of the side to which said Hara fuel gas and said oxidation gas are supplied, and the fuel spray of said liquid was carried out is cooled at this time. the generated hydrogen -- rich fuel gas is discharged from said catalyst section.

[0053] According to such a fuel reformer, in the portion of the side to which said Hara fuel gas and said oxidation gas are supplied, since the fuel spray of the liquid which consists at least of one side among said hydrocarbon and water is carried out, a part of heat produced by said oxidation reaction is consumed as heat of vaporization, and temperature does not rise too much to the side to which said oxidation gas is supplied. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly.

[0054] The steam-reforming reaction which the 11th fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The 1st reaction section equipped with the catalyst which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and promotes said steam-reforming reaction and said oxidation reaction, The catalyst section equipped with the 2nd reaction section equipped with the catalyst which promotes said steam-reforming reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon and steam to said catalyst section, An oxidation gas supply means to supply the oxidation gas containing oxygen to said 1st reaction section, It has a fuel gas discharge means to discharge rich fuel gas from said catalyst section. the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- said catalyst section Said 1st

reaction section and said 2nd reaction section are made to adjoin, and let it be a summary to make heat exchange perform between said 1st reaction section and said 2nd reaction section.

[0055] The 11th fuel reformer of this invention constituted as mentioned above If the original fuel gas containing a hydrocarbon and a steam and the oxidation gas containing oxygen are supplied to the 1st reaction section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, it will set in this 1st reaction section. It is a reaction accompanied by an endothermic and the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon are gone on. Moreover, if said Hara fuel gas is supplied to the 2nd reaction section equipped with the catalyst which promotes said steam reaction, said steam-reforming reaction will be gone on in this 2nd reaction section. Here, although said steam-reforming reaction advances in said 1st reaction section using the heat produced in said oxidation reaction, said steam-reforming reaction advances using the heat produced in said oxidation reaction in said 1st reaction section by carrying out heat exchange also of said 2nd reaction section to said 1st adjoining reaction section. the generated hydrogen -- rich fuel gas is discharged from said catalyst section.

[0056] In the field in which according to such a fuel reformer said oxidation gas is supplied and said oxidation reaction advances in said 1st reaction section, the heat produced by said oxidation reaction is also told to the 2nd reaction section which it is used for said steam-reforming reaction which advances in said 1st reaction section, and also adjoins, and is used also for said steam-reforming reaction which advances in this 2nd reaction section. Therefore, the temperature of said catalyst section can rise too much with the heat produced in oxidation reaction, un-arranging [which it is called generating of catalyst de-activation or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly.

[0057] Here, in the 5th of the 1st of this invention, the 2nd fuel reformer, or this invention thru/or the 10th fuel reformer, the catalyst which said hydrocarbon is a methanol and promotes said steam-reforming reaction and said oxidation reaction is good also as being a single copper system catalyst.

[0058] Moreover, in the 3rd of this invention, or the 4th fuel reformer, said hydrocarbon is a methanol and good also as the catalyst which promotes said steam-reforming reaction, and the catalyst which promotes said oxidation reaction being the same copper system catalysts.

[0059] Moreover, in the 11th fuel reformer of this invention, said hydrocarbon is a methanol and the catalyst with which said 1st reaction section is equipped is good also as being a single copper system catalyst.

[0060] In such a fuel reformer of a configuration, the steam-reforming reaction of a methanol and oxidation reaction of a methanol are promoted by the single copper system catalyst. Unlike the case where it promotes oxidation reaction using other oxidation catalysts known conventionally [, such as platinum,] in promoting oxidation reaction of a methanol according to a copper system catalyst, most advancing oxidation reaction turns into a reaction which does not produce a carbon monoxide. Therefore, fuel gas with more low carbon monoxide concentration is generable by considering as such a configuration.

[0061] The steam-reforming reaction which the 12th fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon, steam, and oxygen to said catalyst section, It has a fuel gas discharge means to discharge rich fuel gas from said catalyst section. the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- said catalyst Let it be a summary to promote the reaction which does not go via the reaction path which generates a carbon monoxide as said oxidation reaction.

[0062] Since said catalyst can promote said oxidation reaction which does not go via the reaction path which generates a carbon monoxide according to such a fuel reformer, the amount of carbon monoxides produced by the reaction which advances in the catalyst department can be stopped, and fuel gas with low carbon monoxide concentration can be generated.

[0063] In the 12th fuel reformer of this invention, said hydrocarbon is a methanol and the catalyst which promotes said steam-reforming reaction and said oxidation reaction is good also as being a single copper system catalyst.

[0064] Unlike the case where oxidation reaction is promoted using other oxidation catalysts known conventionally [, such as platinum,] in order to promote oxidation reaction of a methanol according to a copper system catalyst, in such a fuel reformer of a configuration, most advancing oxidation reaction turns into a reaction which does not produce a carbon monoxide. Therefore, fuel gas with more low carbon monoxide concentration is generable by considering as

such a configuration. Moreover, since the steam-reforming reaction of a methanol and oxidation reaction of a methanol are promoted by the single copper system catalyst, the configuration of a fuel reformer can be simplified according to it.

[0065]

[Embodiment of the Invention] In order to clarify further a configuration and an operation of this invention explained above, the gestalt of operation of this invention is explained based on an example below. Drawing 1 is an outline block diagram which illustrates the configuration of fuel cell equipment 20 equipped with the reforming machine which is the 1st suitable example of this invention. a fuel cell -- equipment -- 20 -- a methanol -- storing -- a methanol -- a tank -- 22 -- water -- storing -- a water tank -- 24 -- combustion gas -- generating -- a burner -- 26 -- air -- compression -- carrying out -- a compressor -- 28 -- a burner -- 26 -- a compressor -- 28 -- having annexed -- an evaporator -- 32 -- reforming -- a reaction -- fuel gas -- generating -- reforming -- a vessel -- 34 -- fuel gas -- inside -- a carbon monoxide -- (-- CO --) -- concentration -- decreasing First, the fuel cell 40 which is the subject of the generation of electrical energy in fuel cell equipment 20 is explained.

[0066] A fuel cell 40 is a fuel cell of a solid-state polyelectrolyte mold, and has the stack structure which carried out two or more laminatings of the single cel which is a configuration unit. Drawing 2 is a cross section which illustrates the configuration of the single cel 48 which constitutes a fuel cell 40. The single cel 48 consists of an electrolyte film 41, a cathode 42 and an anode 43, and separators 44 and 45.

[0067] A cathode 42 and an anode 43 are gas diffusion electrodes which constitute sandwich structure on both sides of the electrolyte film 41 from both sides. Separators 44 and 45 form the passage of fuel gas and oxidation gas between a cathode 42 and an anode 43, sandwiching this sandwich structure from both sides further. Fuel gas passage 44P are formed between the cathode 42 and the separator 44, and oxidation gas-passageway 45P are formed between the anode 43 and the separator 45. Although separators 44 and 45 form passage only in one side in drawing 2, respectively, the rib is formed in the both sides in fact, one side forms fuel gas passage 44P between cathodes 42, and other sides form oxidation gas-passageway 45P between the anodes 43 with which the adjoining single cel is equipped. Thus, separators 44 and 45 have played the role which separates the flow of fuel gas and oxidation gas between the adjoining single cels while forming a gas passageway between gas diffusion electrodes. In case the laminating of the single cel 48 is carried out and stack structure is formed from the first, the separator of two sheets located in the both ends of stack structure is good also as forming a rib only in one side which touches a gas diffusion electrode.

[0068] Here, the electrolyte film 41 is the ion exchange membrane of proton conductivity formed by solid-state polymeric materials, for example, fluorine system resin, and shows good electrical conductivity according to a damp or wet condition. The Nafion film (Du Pont make) was used in this example. The alloy which consists of the platinum as a catalyst or platinum, and other metals is supported by the surface of the electrolyte film 41.

[0069] Both the cathode 42 and the anode 43 are formed of the carbon crossing woven with the thread which consists of a carbon fiber. In addition, a cathode 42 and an anode 43 are formed by carbon crossing, and also the configuration formed by the carbon paper which consists of a carbon fiber, or carbon felt is suitable for them.

[0070] Separators 44 and 45 are formed by the conductive gas non-penetrated member, for example, the substantia-compacta carbon which compressed carbon and it presupposed gas un-penetrating. Separators 44 and 45 form in the both sides two or more ribs arranged in parallel, and as mentioned already, fuel gas passage 44P are formed on the surface of a cathode 42, and they form oxidation gas-passageway 45P on the surface of the anode 43 of the adjoining single cel. Here, the rib formed in the surface of each separator is good also as making a predetermined angle -- it is not necessary to form both sides in parallel, and they go direct for every field. Moreover, it does not need to be an parallel groove, and if supply of fuel gas or oxidation gas is possible for the configuration of a rib to a gas diffusion electrode, it is good.

[0071] In the above, the configuration of the single cel 48 which is the basic structure of a fuel cell 40 was explained. When actually assembling as a fuel cell 40, stack structure is constituted by carrying out two or more set laminating of a separator 44, a cathode 42, the electrolyte film 41, an anode 43, and the single cel 48 constituted in order of a separator 45 (this example 100 sets), and arranging the collecting electrode plate formed in the both ends by substantia-compacta carbon, a copper plate, etc.

[0072] Hereafter, sequential explanation is given about the components and those connection relation other than fuel cell 40 which constitutes fuel cell equipment 20. An evaporator 32 is equipment which supply of a methanol and water is received [equipment] from the methanol tank 22 and a water tank 24, and makes these methanols and water evaporate. although the burner 26 and the compressor 28 are put side by side as mentioned already, the combustion gas of a burner 26 is drawn through a compressor 28 so that it may mention later, this heat of combustion is told to the heat exchanger with which an evaporator 32 is equipped and which is not a drawing example, and an evaporator 32 boils the

methanol and water which were supplied to the evaporator 32, and is made to evaporate

[0073] The 2nd pump 71 is formed in the methanol passage 60 which sends into an evaporator 32 the methanol which is a original fuel from the methanol tank 22, and the amount of methanols supplied to an evaporator 32 can be adjusted. This 2nd pump 71 is connected to the control section 50, it drives with the signal outputted from a control section 50, and the methanol flow rate supplied to an evaporator 32 is adjusted.

[0074] The 3rd pump 72 is formed in the water supply way 62 which sends water into an evaporator 32 from the water tank 24, and the amount of the water supplied to an evaporator 32 can be adjusted. This 3rd pump 72 is connected to the control section 50 as well as the 2nd pump 71, it drives with the signal outputted from a control section 50, and the amount of water supplied to an evaporator 32 is adjusted. The above-mentioned methanol passage 60 and the water supply way 62 join, the 1st fuel-supply way 63 is formed, and this 1st fuel-supply way 63 is connected to an evaporator 32. Since a methanol flow rate and amount of water are adjusted with the 2nd pump 71 of the above, and the 3rd pump 72, the methanol and water which were mixed the specified quantity every are supplied to an evaporator 32 through the 1st fuel-supply way 63.

[0075] The compressor 28 put side by side to the evaporator 32 is equipment for incorporating air from the exterior of fuel cell equipment 20, compressing this, and supplying this compressed air to the anode plate side of a fuel cell 40. A compressor 28 is equipped with turbine 28a and compressor 28b, and these are fabricated by the impeller mold. Turbine 28a and compressor 28b are connected by shaft 28c on the same axle, and can carry out the rotation drive of the compressor 28b by carrying out the rotation drive of the turbine 28a. Although the burner 26 is further put side by side to the evaporator 32, turbine 28a drives by the hot combustion gas of this burner 26. Compressor 28b also rotates with rotation of turbine 28a, and this compressor 28b compresses air, as mentioned already. To compressor 28b, the air which the incorporation of air has become possible from the exterior through the air installation way 29, and was compressed with the compressor 28 is supplied to a fuel cell 40 through the oxidation gas supply way 68, and the electrochemical reaction in a fuel cell 40 is presented with it.

[0076] Here, since turbine 28a is driven by the hot combustion gas of a burner 26, in order to realize thermal resistance and endurance, it is formed with superalloy, the ceramics, etc. In this example, the alloy (Inconel 700, Inconel company) of the nickel base was used. Moreover, compressor 28b is formed with a lightweight aluminium alloy.

[0077] The fuel for combustion is supplied to the burner 26 which drives turbine 28a from the cathode side of a fuel cell 40, and the methanol tank 22. Although a fuel cell 40 uses as a fuel the hydeogen-rich gas which reformed and generated the methanol with the reforming vessel 34 and electrochemical reaction is performed, the fuel exhaust gas containing the hydrogen which remained without not consuming all the hydrogen supplied to the fuel cell 40 in electrochemical reaction, and being consumed is discharged by the fuel exhaust passage 67. The perfect combustion of the hydrogen which it connected with this fuel exhaust passage 67, and the burner 26 received supply of fuel exhaust gas, and remained, without being consumed is carried out, and improvement in the utilization factor of a fuel is in drawing. Usually, only with such exhaust fuel, since it runs short as a fuel for the combustion reaction in a burner 26, the fuel for the combustion reaction in the burner 26 in case there is nothing a carrier eclipse about supply of exhaust fuel is supplied from the methanol tank 22 from a fuel cell 40 to a burner 26 like [at the time of starting of the fuel equivalent to this insufficiency and fuel cell equipment 20]. In order to supply a methanol to a burner 26, the methanol fork road 61 is formed. This methanol fork road 61 has branched from the methanol passage 60 which supplies a methanol to an evaporator 32 from the methanol tank 22.

[0078] Here, the 1st temperature sensor 73 is formed in the burner 26, the temperature of the heat of combustion in a burner 26 was measured, and this measurement result is inputted into the control section 50. Based on the input result from this 1st temperature sensor 73, a control section 50 outputs a driving signal to the 1st pump 70, adjusts the amount of methanols supplied to a burner 26, and is maintaining the combustion temperature in a burner 26 at the predetermined range (from about 800 degrees C to 1000 degrees C). After the combustion gas in this burner 26 carries out the rotation drive of the turbine 28a, it is led to an evaporator 32. Since the heat exchange effectiveness in turbine 28a is not not much high (less than about 10%), the temperature of the combustion gas led to an evaporator 32 amounts to about 600-700 degrees C, and becomes enough as a heat source of an evaporator 32. The mixed solution of the methanol and water which were supplied through the 1st fuel-supply way 63 mentioned already is made to evaporate here with the elevated-temperature combustion gas of the burner 26 led to the evaporator 32. The original fuel gas which consists of a methanol evaporated with the evaporator 32 and water is led to the 2nd fuel-supply way 64, and is told to the reforming machine 34.

[0079] the original fuel gas with which the reforming machine 34 consists of a supplied methanol and water -- reforming -- hydrogen -- rich fuel gas is generated. The reforming reaction performed with the configuration of this reforming machine 34 and the reforming vessel 34 corresponds to the important section of this invention, and is

explained in full detail behind. In addition, the 2nd temperature sensor 74 is formed in the 2nd fuel-supply way 64 which supplies the original fuel gas which becomes the reforming machine 34 from a methanol and water, and the temperature of the original fuel gas which consists of a methanol supplied to the reforming machine 34 and water is measured. The measurement result about the temperature of this original fuel gas is inputted into a control section 50. In case a control section 50 outputs a driving signal to the 1st pump 70 based on the input result from the 1st temperature sensor 73 mentioned already, it amends the amount of drives of the 1st pump 70 of the above based on the signal from this 2nd temperature sensor 74, and adjusts the amount of methanols supplied to a burner 26. Thus, by controlling the temperature of the combustion gas in a burner 26, the temperature of the above-mentioned Hara fuel gas evaporated with the evaporator 32 is adjusted. The temperature up of the original fuel gas supplied from an evaporator 32 is usually carried out to about 250 degrees C.

[0080] Moreover, at the reforming reaction in the reforming machine 34, oxygen involves so that it may mention later, but in order to supply oxygen required for this reforming reaction, the blower 38 is put side by side in the reforming vessel 34. A blower 38 supplies the air which incorporated air from the exterior, and compressed and incorporated this to the reforming machine 34 through the air supply way 39. In this example, the air supply way 39 is connected to the 2nd fuel-supply way 64, and the air which the blower 38 incorporated is supplied to the reforming machine 34 with the original fuel gas supplied from an evaporator 32. The blower 38 is connected to the control section 50, and the drive condition is controlled by the control section 50.

[0081] CO reduction section 36 is equipment which reduces the carbon monoxide concentration in the fuel gas supplied from the reforming machine 34 through the 3rd fuel-supply way 65. Although the general reforming reaction of a methanol was already shown in (4) types, when a reforming reaction is actually performed, as expressed to these formulas, a reaction does not necessarily advance ideally, and the fuel gas generated with the reforming vessel 34 contains the carbon monoxide of the specified quantity. Then, reduction of the carbon monoxide concentration in the fuel gas supplied to a fuel cell 40 is in drawing by forming CO reduction section 36.

[0082] Although it has the catalyst which consists of the platinum or platinum which the fuel cell 40 of this example is a fuel cell of a solid-state macromolecule mold, and promotes a cell reaction, and other metals (the platinum catalyst was applied to the surface of the electrolyte film 41 in this example) When a carbon monoxide is contained in fuel gas, this carbon monoxide sticks to a platinum catalyst, the function as a catalyst is reduced, the reaction in the anode shown in (1) type will be checked, and the engine performance of a fuel cell will be reduced. Therefore, in order to generate electricity using the fuel cell of a solid-state macromolecule mold like a fuel cell 40, it becomes indispensable to reduce the carbon monoxide concentration in the fuel gas to supply below to the specified quantity, and to prevent cell performance degradation. In addition, in such a polymer electrolyte fuel cell, the threshold limit value as carbon monoxide concentration in the fuel gas supplied is usually about several ppm or less.

[0083] The fuel gas supplied to CO reduction section 36 is hydeogen-rich gas containing the carbon monoxide of the specified quantity, as described above, in CO reduction section 36, priority is given over the hydrogen in fuel gas, and oxidation of a carbon monoxide is performed. CO reduction section 36 is filled up with the support which supported the platinum catalyst which is a selective oxidation catalyst of a carbon monoxide, the ruthenium catalyst, the palladium catalyst, the golden catalyst, or the alloy catalyst that made these the 1st element. The carbon monoxide concentration in the fuel gas processed in this CO reduction section 36 becomes settled with the operating temperature of CO reduction section 36, the carbon monoxide concentration in the fuel gas supplied, the supply flow rate of the fuel gas per unit catalyst volume to CO reduction section 36, etc. The carbon monoxide concentration sensor which is not illustrated is formed in CO reduction section 36, and the operating temperature and the fuel gas flow rate to supply of CO reduction section 36 are adjusted based on this measurement result, and it is controlling so that the carbon monoxide concentration in the fuel gas after processing is set to several ppm or less.

[0084] The fuel gas with which carbon monoxide concentration was lowered as mentioned above in CO reduction section 36 is led to a fuel cell 40 by the 4th fuel-supply way 66, and the cell reaction by the side of cathode is presented with it. As mentioned already, fuel exhaust gas after being used for the cell reaction with the fuel cell 40 is discharged by the fuel exhaust passage 67, is led to a burner 26, and it is consumed as a fuel for combustion of the hydrogen which remains into this fuel exhaust gas. On the other hand, the oxidation gas in connection with the cell reaction by the side of the anode plate of a fuel cell 40 is supplied as the compressed air through the oxidation gas supply way 68 from a compressor 28, as mentioned already. The remaining oxidation exhaust gas used for the cell reaction is discharged outside through the oxidation exhaust gas way 69.

[0085] A control section 50 is constituted as a logical circuit centering on a microcomputer. In detail CPU54 which performs a predetermined operation etc. according to the control program set up beforehand, ROM56 in which a control program, control data, etc. required at CPU54 to perform various data processing were stored beforehand, RAM58 by

which various data required to carry out various data processing by CPU54 similarly is written temporarily, While inputting the detecting signal from the various temperature sensors mentioned already, it has the input/output port 52 grade which outputs a driving signal to the various pumps mentioned already according to the result of an operation in CPU54, a blower 38, etc.

[0086] Next, the configuration of the reforming machine 34 corresponding to the important section of this invention is explained. Drawing 3 is explanatory drawing which expresses the outline of the configuration of the reforming machine 34 typically. The reforming machine 34 of this example receives supply of Hara fuel gas and air from the near edge linked to the 2nd fuel-supply way 64, and a steam-reforming reaction and oxidation reaction (partial oxidation reaction) are presented with these Hara fuel gas and air, passing through the interior of the reforming machine 34. the hydrogen generated by the oxidation reaction shown in the steam-reforming reaction shown in (4) types in the reforming machine 34, and (5) types -- rich fuel gas is discharged by the 3rd fuel-supply way 65 from another edge. This reforming machine 34 equips that interior with the 1st reaction section 80 and the 2nd reaction section 81. These 1st reaction section 80 and the 2nd reaction section 81 are constituted by the surface as a metal honeycomb which supported the Cu-Zn catalyst, and the 1st reaction section 80 formed in the upstream (side near a connection with the 2nd fuel-supply way 64) is formed so that the number of cels mentioned later may become less than the 2nd reaction section 81 formed in the downstream (side near a connection with the 3rd fuel-supply way 65).

[0087] Drawing 4 is a mimetic diagram showing a part of cross section of the metal honeycomb which forms the 1st reaction section 80 and the 2nd reaction section 81. A metal honeycomb carries out the laminating of the stainless plates 82 and 83, and is formed. That is, the plate-like stainless plate 82 and the stainless plate 83 bent in the shape of a wave are arranged by turns, and the metal honeycomb is formed. Since the stainless plate 83 is bent in the shape of a wave at intervals of 1mm, it can form the honeycomb which a length of one side becomes from the cel which has the cross section of the abbreviation square which is 1mm by carrying out the laminating of this stainless plate 83 and the plate-like stainless plate 82 by turns.

[0088] Here, in the 1st reaction section 80 and the 2nd reaction section 81, the thickness of the stainless plates 82 and 83 used in order to form a metal honeycomb differs, and of this, the numbers of cels which each equips with the 1st reaction section 80 and the 2nd reaction section 81 differ, and it is formed. The 1st reaction section 80 consists of a honeycomb formed by the stainless plates 82 and 83 whose thickness is 0.1mm, and the 2nd reaction section 81 consists of a honeycomb formed by the stainless plates 82 and 83 whose thickness is 0.03mm. Therefore, the 1st reaction section 80 is 2 the cross section of 1cm. Having the cel of about 75 hits, similarly the 2nd reaction section 81 is 2 1cm. It will have the cel of about 91 hits. In the reforming machine 34 whole, the gross area (total of the cross section of each cel which constitutes the 1st reaction section 80) of the cross section of the gas passageway in the 1st reaction section 80 becomes smaller than the gross area (total of the cross section of each cel which constitutes the 2nd reaction section 81) of the cross section of the gas passageway in the 2nd reaction section 81 by constituting a honeycomb with the stainless plate with which thickness differs as described above, since the cross section is fixed.

[0089] since the 1st reaction section 80 and the 2nd reaction section 81 are supporting the catalyst on the honeycomb surface which constitutes each, if original fuel gas is supplied from the upstream, while passing through the above-mentioned honeycomb surface, they will present a steam-reforming reaction and oxidation reaction with original fuel gas -- having -- hydrogen -- it becomes rich fuel gas. In this example, the catalyst which the honeycomb surface is made to support was manufactured with the coprecipitation method using copper and a zinc oxide. The Cu-Zn catalyst acquired with the coprecipitation method can grind this, can add binders, such as alumina sol, further, and can be made to support them on a honeycomb by the method of applying on a honeycomb.

[0090] If original fuel gas is supplied to the reforming machine 34 constituted as mentioned above, original fuel gas will pass through the inside of the 1st reaction section 80 with the small gross area of a gas-passageway cross section with few [namely,] cels first, next will pass through many [the number of cels / namely,] inside of the 2nd reaction section 81 with the large gross area of a gas-passageway cross section. Thus, after the original fuel gas of the specified quantity passes through the inside of a honeycomb with the small gross area of a gas-passageway cross section, in order to pass through the inside of a honeycomb with the large gross area of a gas-passageway cross section, the rate of flow of the original fuel gas which passes through the inside of the reforming machine 34 becomes quicker than the time of the direction when passing through the inside of the 1st reaction section 80 passing through the inside of the 2nd reaction section 81.

[0091] Therefore, according to the reforming machine 34 of the 1st example, by making quick the rate of flow of the original fuel gas in the upstream, the rapid temperature rise in the upstream is suppressed and the effect of equalizing the temperature-distribution condition in [whole] the reforming machine 34 in the 250-300-degree C temperature requirement which is a temperature requirement suitable for a reforming reaction is done so. Drawing 5 is explanatory

drawing which expressed the temperature-distribution condition of the interior about the flow direction of gas about the reforming machine known conventionally [with the fixed honeycomb cross section], and the reforming machine 34 of this example. As mentioned already, since the reaction rate is quicker than a steam-reforming reaction, with the conventional reforming vessel, oxidation reaction will advance actively near the entry section of original fuel gas, and, as for oxidation reaction, the temperature near [this] the entry section will rise at about 400 degrees C. On the other hand, with the reforming vessel 34 of this example, since the rate of flow of the original fuel gas in the upstream is quick, the heat produced by the oxidation reaction which advanced by the upstream is promptly carried to the downstream by the flow of quick gas. Moreover, since the rate of flow of the original fuel gas in the upstream is quick, the field where oxidation reaction is not completed in the narrow field of the upstream, and oxidation reaction advances actively spreads in the downstream more. Therefore, temperature does not rise rapidly near the entry section. Furthermore, since the 1st reaction section 80 arranged in the upstream is equipped with the honeycomb formed using the thick stainless plate, it has big heat capacity, and the heat produced in oxidation reaction has become that it is easy to be told to the downstream by the flow of gas, before being told to this honeycomb and carrying out the temperature up of the honeycomb.

[0092] Thus, since temperature does not rise rapidly near [the] the entry section, the reforming machine 34 can prevent un-arranging [which it is called generating of the catalyst de-activation resulting from a temperature rise mentioned already, or a by-product]. By suppressing deterioration of a catalyst, it became possible to raise the endurance of a reforming machine greatly, and, as for the reforming machine 34 of this example, use of 5000 hours or more was attained to having been the endurance whose conventional reforming machine is about time 200 hour.

[0093] Moreover, as described above, while the field where oxidation reaction advances spreads in the downstream, with the reforming vessel 34 of this example, temperature does not fall too much like the reforming machine conventional by the downstream by carrying promptly the heat produced in the oxidation reaction which advanced by the upstream to the downstream. Therefore, also in the downstream of a reforming machine, it is maintained at the condition that the activity of a steam-reforming reaction is high, and while also fully being able to use the catalyst with which the downstream is equipped, the speed of a steam-reforming reaction can be raised. Thus, it becomes possible by raising the activity of the steam-reforming reaction in the downstream to use a reforming machine as a compact more.

[0094] Although the honeycomb with which the reforming machine 34 is equipped considered as the metal honeycomb in the 1st above-mentioned example, it is good also as using a ceramic honeycomb. The configuration using a metal honeycomb is shown below as a modification of the 1st example. The reforming machine in this modification as well as the reforming machine 34 of the 1st example consists of the 1st reaction section 80 and the 2nd reaction section 81. The mimetic diagram of the cross section of the 1st reaction section 80 formed by the ceramic honeycomb and the 2nd reaction section 81 is shown in drawing 6. Drawing 6 (A) expresses the 2nd reaction section 81 which constitutes an example of the 1st reaction section 80 constituted from a ceramic honeycomb, and drawing 6 (B) from other examples of the 1st reaction section 80, and similarly constitutes drawing 6 (C) from a ceramic honeycomb.

[0095] In drawing 6 (A), the gross area of the passage cross section of gas is made small compared with the honeycomb of drawing 6 (C) by forming small the cross section of each cel which constitutes a honeycomb, respectively, and lessening the total of the cel which constitutes a honeycomb from drawing 6 (B). Therefore, also when using which the 1st reaction section 80 of drawing 6 (A) and drawing 6 (B), the same effect as the 1st example mentioned already can be acquired by constituting the reforming machine 34 combining the 2nd reaction section 81 expressed to drawing 6 (C).

[0096] Moreover, although considered as the configuration from which the rate of flow of the original fuel gas which divides the interior of the reforming machine 34 into two, the 1st reaction section 80 and the 2nd reaction section 81, and passes through the interior in the section the first portion and the second half differs in the above-mentioned example, it is good also as a configuration which divides the interior of a reforming machine or more into three. Also in this case, the same effect as the above-mentioned example can be acquired by considering as the configuration to which the gas flow rate of the upstream becomes quicker than the downstream.

[0097] In the example mentioned already, the gross area of the gas-passageway cross section in the upstream is made small in the honeycomb arranged in the upstream of a reforming machine compared with the downstream by lessening the number of the cels per unit cross section, or forming the cross section of each cel small. The configuration which forms the cross section of the whole reforming machine other than a configuration of having mentioned already as a configuration of the reforming machine with which the gas flow rate of the upstream becomes quicker than the downstream so that it may become smaller by the upstream can be mentioned. The configuration of such reforming machine 34A is shown in drawing 7. Reforming machine 34A consists of three honeycombs from which a gross area differs, and is formed of as small the honeycomb of a gross area as the upstream. Since such a configuration, then the gas flow rate of the upstream become quicker than the downstream, the same effect as the example mentioned already

can be acquired. The temperature-distribution condition of the interior in reforming machine 34A is shown in drawing 5. If it considers as the configuration which enlarges the gross area of the whole reforming machine gradually like the above-mentioned reforming machine 34A, the number of cels per unit cross section and the cross section of each ** cel may be the same. Moreover, if it is good also as consisting of two or more parts other than three and the upstream is considered as the configuration to which the gross area of a passage cross section becomes small in case two or more parts where gross areas differ constitute a reforming machine, the effect mentioned already can be acquired.

[0098] Next, the configuration which holds the catalyst which promotes a steam-reforming reaction and oxidation reaction by the support formed with a thermally conductive, comparatively high material as other configurations which transmit positively to the downstream the heat produced by the oxidation reaction which advances in the upper section of a reforming machine is explained below as the 2nd example. Drawing 8 is explanatory drawing which expresses the configuration of the reforming machine 90 of the 2nd example typically. The fuel cell equipment 20 of drawing 1 and the fuel cell equipment of the same configuration are equipped with the reforming machine 90 of the 2nd example. As shown in drawing 8, the reforming machine 90 consists of the single reaction section 92 constituted by the honeycomb. Drawing 9 (A) of the honeycomb which showed the cross section showing a part of cross section of the honeycomb which constitutes this reaction section 92 to drawing 9 (A) again at drawing 9 (A) was expanded further is shown in drawing 9 (B).

[0099] The reforming machine 90 of this example is constituted by the metal honeycomb like the reforming machine 34 of the 1st example. In addition, in this example, thickness formed the honeycomb using the stainless plate 94 which is 0.05mm. The catalyst which promotes a steam-reforming reaction and oxidation reaction is contained in the surface of this stainless plate 94, and the catalyst bed 96 whose thickness is about 0.05mm is formed in it. At the catalyst bed 96, the copper content child and zinc oxide molecule which constitute a Cu-Zn catalyst are supported with the condition of having distributed in the thermally conductive high binder.

[0100] Here, the preparation method of a catalyst bed 96 is explained. First, as a catalyst raw material, CuO-ZnO powder is produced with a well-known coprecipitation method, and thermally conductive high material is added [alumina sol 5% / further] at this to an aluminum oxide as a binder. It is carbonization silicon (SiC) and boron carbide (B4C) which are the alumimium nitride (AlN) which is a nitride, titanium nitride (TiN), or carbide as thermally conductive high material used here, Or graphite etc. can be mentioned and 5 - 30% is desirable as an addition. For example, in the above-mentioned thermally conductive high material, AlN shows 0.07 cal/cm/s/degree C thermal conductivity, SiC shows 0.1cal/cm/s/degree C, graphite shows 0.30.1 cal/cm/s/degree C thermal conductivity, and all show high thermal conductivity compared with the aluminum oxide (0.02cal/cm/s/degree C) used conventionally.

[0101] These are diluted with water, grinding mixing is carried out with a ball mill, it applies on a stainless plate 94, and heat-treatment and reduction processing are performed further. By such processing, the above-mentioned catalyst raw material serves as a Cu-Zn catalyst which consists of a copper content child and a zinc-oxide molecule, and these Cu-Zn catalysts are in the condition distributed and supported in the binder containing thermally conductive high material, and form a catalyst bed 96.

[0102] If the reforming machine 90 constituted as mentioned above is applied to fuel cell equipment 20 and original fuel gas is supplied to the reforming machine 90, as mentioned already, in the upstream to which oxygen is supplied, oxidation reaction will be performed actively and many heat will arise. Thus, the inside of the binder containing the thermally conductive high material which it was used at the steam-reforming reaction which advances by the upstream, and also was mentioned already is promptly told to the heat produced by oxidation reaction. Thus, the specified quantity of the heat to which the inside of a binder is told is further told to the honeycomb base material formed with thermally conductive high stainless steel. The heat told to the honeycomb base material which consists of stainless steel is told to the downstream through this honeycomb base material. Moreover, the inside of a binder is told to the remaining heat which is not told to a honeycomb base material by the downstream as it is. Thus, the heat told to the downstream of the reforming machine 90 is used at the steam-reforming reaction which advances by the downstream.

[0103] Therefore, according to the reforming machine 90 of this example, since the catalyst is supported in the thermally conductive high binder, the heat produced in the upstream for oxidation reaction is promptly told to the downstream, and the rapid temperature rise in the upstream can be suppressed. Drawing 10 is explanatory drawing which stuck with the reforming machine known conventionally using the binder which does not contain the high material of the above-mentioned pyroconductivity, and the reforming machine 90 of this example, and expressed the temperature-distribution condition of the interior about the flow direction of gas. The reforming machine 90 of this example can equalize the internal temperature of a reforming machine in a 250-300-degree C temperature requirement, without carrying out the temperature up of the upstream rapidly, since the heat produced in the oxidation reaction which

advances by the upstream is promptly told to the downstream unlike the conventional reforming machine. Thus, since temperature does not rise rapidly near [the] the entry section, the reforming machine 90 can prevent un-arranging [which it is called generating of the catalyst de-activation resulting from a temperature rise mentioned already, or a by-product]. By suppressing deterioration of a catalyst, it became possible to raise the endurance of a reforming machine greatly, and, as for the reforming machine 90 of this example, use of 5000 hours or more was attained to having been the endurance whose conventional reforming machine is about time 200 hour.

[0104] Moreover, since the heat produced by the oxidation reaction which advanced by the upstream is promptly told to the downstream as described above, with the reforming vessel 90 of this example, temperature does not fall too much like the reforming machine conventional in the downstream region. Therefore, also in the downstream of a reforming machine, it is maintained at the condition that the activity of a steam-reforming reaction is high, and while also fully being able to use the catalyst with which the downstream is equipped, the speed of a steam-reforming reaction can be raised. Therefore, it becomes possible to use a reforming machine as a compact more.

[0105] In the 2nd example of the above, since the catalyst bed 96 using the binder containing thermally conductive high material formed on the honeycomb which uses the stainless plate excellent in thermal conductivity as a base material, heat conduction from the upstream to a lower stream of a river was able to acquire what is depended on catalyst bed 96 self, and the effect which both were performed through the stainless plate 94, and could perform heat transfer and were especially excellent in high effectiveness. Here, a catalyst bed 96 can be formed on a ceramic honeycomb, or a catalyst can be fabricated to a pellet type with a thermally conductive high binder, and the predetermined effect by the thermal conductivity from the upstream to the downstream improving also as a configuration with which it is filled up in a reforming machine can be acquired.

[0106] Next, by lessening the amount of catalysts which the upstream in a reforming machine supports as the 3rd example compared with the downstream shows below the configuration which suppressed the activity of oxidation reaction in the upstream. Drawing 11 is explanatory drawing which expresses the configuration of the reforming machine 100 of the 3rd example typically. The fuel cell equipment 20 of drawing 1 and the fuel cell equipment of the same configuration are equipped with this reforming machine 100. As shown in drawing 11, the reforming machine 100 is equipped with the 1st reaction section 101 and the 2nd reaction section 102. These 1st reaction section 101 and the 2nd reaction section 102 are constituted by the honeycomb of the same configuration, and although the same Cu-Zn catalyst as the example mentioned already on this honeycomb surface is supported, the amount of the 2nd reaction section 102 of the catalyst supported on the honeycomb is more than the 1st reaction section 101. That is, the 2nd reaction section 102 is supporting the Cu-Zn catalyst with the rate of 180 g/l to the 1st reaction section 101 supporting the Cu-Zn catalyst with the rate of 50 g/l (the amount of catalysts per unit volume of a honeycomb).

[0107] Since there are few amounts of catalysts which the 1st reaction section 101 of the upstream supports according to the reforming machine 100 constituted as mentioned above, advance of the oxidation reaction by the installation side of original fuel gas and air is suppressed. Therefore, the field where oxidation reaction does not advance rapidly by the upstream of a reforming machine, and oxidation reaction is performed spreads in the downstream more. Therefore, the rapid temperature rise in the upstream can be suppressed.

[0108] Drawing 12 is explanatory drawing which expressed the temperature-distribution condition of the interior about the flow direction of gas about the reforming machine with which it is known conventionally which was equipped with the honeycomb with which the catalyst of the downstream and takes doses is supported also for the upstream, and the reforming machine 100 of this example. The reforming machine 100 of this example can equalize the internal temperature of a reforming machine in a 250-300-degree C temperature requirement, without carrying out the temperature up of the upstream rapidly, since advance of oxidation reaction is suppressed by the upstream unlike the conventional reforming machine. Thus, since temperature does not rise rapidly near [the] the entry section, the reforming machine 100 can prevent un-arranging [which it is called generating of the catalyst de-activation resulting from a temperature rise mentioned already, or a by-product]. By suppressing deterioration of a catalyst, it became possible to raise the endurance of a reforming machine greatly, and, as for the reforming machine 100 of this example, use of 5000 hours or more was attained to having been the endurance whose conventional reforming machine is about time 200 hour.

[0109] Moreover, since the field where the oxidation reaction accompanied by pyrexia advances spreads in the downstream more as described above, with the reforming vessel 100 of this example, temperature does not fall too much like the reforming machine conventional in the downstream region. Therefore, also in the downstream of a reforming machine, it is maintained at the condition that the activity of a steam-reforming reaction is high, and while also fully being able to use the catalyst with which the downstream is equipped, the speed of a steam-reforming reaction can be raised. Therefore, it becomes possible to use a reforming machine as a compact more.

[0110] In addition, although carried out to changing the amount of catalysts to support to two steps in the reforming machine 100 in the 3rd example of the above, it is good also as making it change more than a three-stage, and the above-mentioned predetermined effect can be acquired by reducing the amount of catalyst support of the upstream. By considering as the configuration whose upstream reduces the amount of support of a catalyst here, and adjusting the number of the phases of changing the amount of support of a catalyst, it becomes possible to make the temperature inside a reforming machine equalize more, and the effect mentioned already can be heightened.

[0111] Moreover, although [the 3rd example of the above / a steam-reforming reaction and oxidation reaction] promoted according to the same Cu-Zn catalyst, it is good also as promoting a steam-reforming reaction and oxidation reaction according to a different catalyst. In such a case, what is necessary is to lessen only the amount of support of the catalyst which promotes oxidation reaction by the upstream instead of changing the total amount of support of a catalyst by the upstream and the downstream of a reforming machine.

[0112] Next, while suppressing the activity of the oxidation reaction by the upstream by lowering the oxygen density in the gas supplied to a reforming machine as the 4th example, the configuration which tells the heat which sped up the rate of flow of the gas to supply and was produced in the oxidation reaction in the upstream to the downstream is shown. Drawing 13 is explanatory drawing which expresses the configuration of the reforming machine 110 of the 4th example typically. The fuel cell equipment 20 of drawing 1 and the fuel cell equipment of the almost same configuration are equipped with this reforming machine 110, and it gives the same member number to a common member, and performs the following explanation.

[0113] Here, although the reforming machine was supplied in the example mentioned already after the air supply way 39 which supplies air to a reforming machine from a blower 38 once joined the 2nd fuel-supply way 64 and original fuel gas had air mixed, direct continuation of the above-mentioned air supply way 39 is carried out to the reforming machine 110 with fuel cell equipment equipped with the reforming machine 110 of the 4th example. Moreover, with fuel cell equipment equipped with the reforming machine 110 of this example, the oxidation exhaust gas discharged by the oxidation exhaust gas way 69 from a fuel cell 40 can also be supplied to the reforming machine 110 with the air incorporated from a blower 38. Although about 20% of oxygen contains to the usual air, since the oxygen of the specified quantity is consumed by electrochemical reaction [in / in the oxidation exhaust gas discharged from a fuel cell / a fuel cell], there are few amounts of oxygen to contain than air. Although the oxygen density in oxidation exhaust gas changes with the excess air factor (the amount of oxygen in the actually supplied air, and the amount of oxygen needed theoretically comparatively) in the oxidation gas supplied to a fuel cell etc., with the fuel cell equipment of this example, the oxygen density in oxidation exhaust gas becomes about 10%. Therefore, it becomes possible by mixing air and oxidation exhaust gas and making supply possible to the reforming machine 110, to adjust the oxygen density in the air supplied to the reforming machine 110 by about 10% - about 20% of within the limits.

[0114] Based on drawing 13, the configuration of the reforming machine 110 is explained in detail. The reforming machine 110 is equipped with the single reaction section 111 constituted by the honeycomb with which the Cu-Zn catalyst was supported by the surface. Moreover, the above-mentioned air supply way 39 and the oxidation exhaust gas way 69 join, and turn into the 2nd air supply way 115, and this 2nd air supply way 115 supplies the mixture of gas (it is hereafter called mixed air) of air and oxidation exhaust gas in the reforming machine 110 to the upstream to which original fuel gas is supplied from the 2nd fuel-supply way 64. The mass flow controller 112 is formed near the unification section to the 2nd air supply way 115, and accommodation of the air content supplied to the 2nd air supply way 115 side is attained on the air supply way 39. Moreover, similarly the mass flow controller 113 is formed near the unification section to the 2nd air supply way 115, and accommodation of the oxidation amount of exhaust gas supplied to the 2nd air supply way 115 side is attained on the oxidation exhaust gas way 69. These mass flow controller 112, 113 is connected to the control section 50 mentioned already, and the amount of mixing at the time of the air supplied from the air supply way 39 and the oxidation exhaust gas supplied from the oxidation exhaust gas way 69 being mixed is controlled by the control section 50. Furthermore, the oxygen density sensor 114 is formed in the 2nd air supply way 115. This oxygen density sensor 114 is also connected to the control section 50, and the information about the oxygen density in mixed air can input into a control section 50. Moreover, in the reaction section 111 interior, the temperature sensor 117 is formed in the position from the edge of the upstream. This temperature sensor 117 is also connected to the control section 50, and the information about the temperature in the reaction section 111 can input into a control section 50.

[0115] It makes the rate of flow of the whole gas which passes through the inside of the reaction section 111 increase, and suppresses that temperature rises rapidly in the upper section of the reforming machine 110 while it reduces the oxygen density in this mixed air, in case the reforming machine 110 of this example supplies the mixed air containing the oxygen of the specified quantity to the reforming machine 110. That is, by reducing the oxygen density in the mixed

air supplied to the reforming machine 110, the oxygen density in the gas which passes through the inside of the reaction section 111 also falls, the activity of the oxidation reaction by the upstream is suppressed by it, and a rapid temperature rise can be prevented by it. Moreover, by reducing the oxygen density in the mixed air containing the oxygen of the specified quantity, the mixed air content supplied to the reaction section 111 increases, and the rate of flow of the gas which passes through the inside of the reaction section 111 speeds up. Before oxygen is used up by it by the oxidation reaction which advances by the upstream, oxygen is carried more to the downstream and the field where oxidation reaction advances can be extended more to the downstream. Furthermore, it can prevent telling the heat produced in the oxidation reaction which advances by the upstream promptly to the downstream, and the upstream of the reaction section carrying out a temperature up too much by speeding up the rate of flow of the gas which passes through the inside of the reaction section 111.

[0116] Drawing 14 is a flow chart showing the amount control manipulation routine of air mixing performed with fuel cell equipment equipped with the reforming machine 110 of this example. In fuel cell equipment equipped with the reforming machine 110, this routine will be performed for every predetermined time amount, if the reforming machine 110 interior is judged to fully have carried out the temperature up and to have reached the steady state after starting of this fuel cell equipment is directed by operating the predetermined start switch which is not illustrated.

[0117] If this routine is performed, CPU54 will read first the amount of methanols in the original fuel gas supplied to the reforming machine 110 based on the amount of drives of the 2nd pump 71 formed in the methanol passage 60 (step S200). Next, based on this amount of methanols, the amount of oxygen which should be supplied to the reforming machine 110 is calculated, and the mass flow controller 112,113 is driven so that supply of the oxygen of an initial complement may be attained (step S210). That is, if the amount of methanols supplied to a reforming machine is determined, since the amount of oxygen required in order to balance the quantity of heat which a steam-reforming reaction takes, and the quantity of heat produced in oxidation reaction can be determined, the mass flow controller 112,113 is driven so that the air containing this determined amount of oxygen may be supplied to the reforming machine 110. Here, when the amount of oxygen which should be supplied is determined, the amount of drives which drives each mass flow controller in order to supply the amount of oxygen which should be supplied is beforehand determined to each amount of supply oxygen as an amount of criteria drives, and is memorized in the control section 50.

[0118] Internal temperature T1 of the upstream in the reaction section 111 from a temperature sensor 117 if it begins to supply the mixed air which drives the mass flow controller 112,113 and contains the oxygen of an initial complement to the reforming machine 110 next It reads (step S220). Next, this internal temperature T1 It compares with the predetermined reference temperature Ta (step S230). Here, it is the predetermined reference temperature Ta. Internal temperature T1 of the upstream It is the value which set up beforehand as a maximum and the control section 50 was made to memorize, and could be 300 degrees C in this example.

[0119] It sets to step S230 and is the internal temperature T1 of the upstream. When smaller than the above-mentioned predetermined reference temperature Ta, it is the internal temperature T1 of the upstream of the reaction section 111. It is judged that it is a temperature low enough and this routine is ended as it is. When the internal temperature T1 of the upstream is more than the above-mentioned predetermined reference temperature Ta, while reducing the amount of drives of the mass flow controller 112, the amount of drives of the mass flow controller 113 is increased. That is, the rate of oxidation exhaust gas is made to increase in the mixed air supplied to the reforming machine 110, without changing the amount of oxygen supplied to per unit time amount (step S240). In this example, the variation of the rate of the oxidation exhaust gas in this step S240, i.e., the variation of the oxygen density in the mixed air supplied to the reforming machine 110, defines the variation of a smallest unit beforehand, and it carried out to reducing an oxygen density for every smallest unit of this. Or internal temperature T1 It is good also as adjusting according to the amount exceeding reference temperature Ta. Since the oxygen density in the whole gas supplied to the reforming machine 110 by making the rate of oxidation exhaust gas increase falls, the oxidation reaction which advances by the upstream is suppressed. Moreover, the mixed air content supplied to the reforming machine 110 increases by making the rate of oxidation exhaust gas increase, without changing the amount of oxygen supplied to per unit time amount, the rate of flow of the gas which passes through the inside of the reforming machine 110 speeds up, and the heat produced in the oxidation reaction which advances by the upstream comes to be more promptly carried to the downstream. Therefore, it is the internal temperature T1 of the upstream of the reaction section 111 by performing step S240. It can lower.

[0120] When the rate of oxidation exhaust gas is changed in step S240 next, it returns to step S220 again, and is the internal temperature T1. Reading and this internal temperature T1 Actuation of the comparison with the predetermined reference temperature Ta is repeated. When the internal temperature T1 becomes lower than the predetermined reference temperature Ta in step S230, the rate of the oxidation exhaust gas in the mixed air supplied to the reforming machine 110 becomes suitable, and it is the internal temperature T1 of the upstream of the reaction section 111. It is

judged that it became low enough and this routine is ended.

[0121] In addition, fuel cell equipment equipped with the reforming machine 110 of this example equips the 2nd air supply way 115 with the oxygen density sensor 114, as mentioned already, and it amends the oxygen density in the mixed air supplied to the reforming machine 110 based on the detection result. That is, in step S210 or step S240 in the above-mentioned amount control manipulation routine of air mixing, when a mass flow controller is driven, the oxygen density sensor 114 detected the oxygen density in the mixed air supplied to the reforming machine 110, and the amount of drives of a mass flow controller is amended based on the result.

[0122] Since the oxygen density in the mixed air supplied to the reforming machine 110 is controllable according to fuel cell equipment equipped with the reforming machine 110 of the 4th example constituted as mentioned above, it can stop that oxidation reaction advances to the installation side of original fuel gas and mixed air by making low the oxygen density in the above-mentioned mixed air. Therefore, the rapid temperature rise in the upstream can be suppressed. Furthermore, supplying the oxygen of the specified quantity to the reforming machine 110 per unit time amount, by lowering the oxygen density in mixed air, the flow rate of mixed air increases and the rate of flow of the gas which passes through the reaction section 111 interior speeds up. Therefore, it can suppress that the heat produced in the oxidation reaction which advances by the upstream is promptly told to the downstream, and temperature rises too much by the upstream.

[0123] Moreover, since the field where oxidation reaction advances by suppressing oxidation reaction in the upstream spreads in the downstream more as described above, with the reforming vessel 110 of this example, temperature does not fall too much like the reforming machine conventional in the downstream region. Furthermore, since the heat produced in the upstream when the rate of flow of the gas which passes through the reaction section 111 interior sped up becomes that it is easy to be told to the downstream, a temperature fall in a downstream region is suppressed further. Therefore, with the reforming vessel 110, it is maintained at the condition that the activity of a steam-reforming reaction is high, also in the downstream, and while also fully being able to use the catalyst with which the downstream is equipped, the speed of a steam-reforming reaction can be raised. Therefore, it becomes possible to use a reforming machine as a compact more.

[0124] In the 4th example of the above, it judges whether the amount of methanols in the original fuel gas supplied to the reforming machine 110 is read based on the amount of drives of the 2nd pump 71 formed in the methanol passage 60, and oxidation reaction is advancing superfluously in the upstream based on the detection result of a temperature sensor 117. It is good also as performing such decision about the amount of methanols supplied to the reforming machine 110, and the advance condition of the oxidation reaction and steam-reforming reaction in the reforming machine 110, using further measurands other than the above, or other than the above. For example, in order to judge the advance condition of the steam-reforming reaction and oxidation reaction in the reforming machine 110 The device which can analyze the component in the gas which passes through the 3rd fuel-supply way 65 is arranged in the 3rd fuel-supply way 65. It is good also as measuring amounts, such as a methanol in the fuel gas discharged from the reforming machine 110, hydrogen, a carbon dioxide, and oxygen, using this measurement result further, and judging the advance condition of the steam-reforming reaction in the reforming machine 110, and oxidation reaction.

[0125] Although mixed air was considered as the configuration supplied only from the upstream of the reforming machine 110 in the 4th example of the above, the configuration which supplies mixed air from two or more places is also desirable. Such a configuration is shown below as a modification of the 4th example. Drawing 15 is explanatory drawing which expresses typically the configuration of reforming machine 110A which is the modification of the 4th example. Reforming machine 110A is equipped with the two reaction sections 111A and 111B, and mixed oxygen is supplied to each reaction section. Here, the original fuel gas supplied to reforming machine 110A is passed in order of the reaction sections 111A and 111B. Moreover, the air supply way 39 and the oxidation exhaust gas way 69 which supply air and oxidation exhaust gas to reforming machine 110A branch to the air fork roads 39A and 39B and the oxidation exhaust gas fork roads 69A and 69B, respectively. Air fork road 39A and oxidation exhaust gas fork road 69A join, turn into 2nd air supply way 115A, and supply mixed air to reaction section 111A arranged in the upstream. Air fork road 39B and oxidation exhaust gas fork road 69B join, turn into 2nd air supply way 115B, and supply mixed air to reaction section 111B arranged in the downstream. The amount of oxygen and oxygen density in the mixed air supplied to each reaction section are controlled like the 4th example based on the amount of methanols supplied to reforming machine 110A, the temperature of the upstream of each reaction section, etc. by adjusting the amount of drives of the mass flow controllers 112A, 112B, 113A, and 113B.

[0126] According to reforming machine 110A constituted as mentioned above, since mixed air is divided and supplied, the amount of oxygen in the mixed gas supplied at once can be reduced, and the effect which prevents temperature rising too much locally can be heightened further. Furthermore, by dividing the interior of a reforming machine into two

or more reaction sections, and supplying mixed air for every reaction section, it becomes possible to control the temperature distribution inside a reforming machine with a more sufficient precision, and the whole interior of a reforming machine can be kept easier to a desirable temperature requirement.

[0127] Drawing 16 is explanatory drawing which stuck with reforming machine 110A mentioned above, and expressed the temperature-distribution condition of the interior about the flow direction of gas as the reforming machine known conventionally supplies only the usual air to a reforming machine as a source of oxygen which oxidation reaction takes. Reforming machine 110A can equalize the internal temperature of a reforming machine in a 250-300-degree C temperature requirement, without carrying out the temperature up of the upstream rapidly, since advance of the oxidation reaction in the upstream is suppressed unlike the conventional reforming machine. As explained above, since temperature does not rise rapidly near [the] the entry section, the reforming machines 110 and 110A of this example can prevent un-arranging [which it is called generating of the catalyst de-activation resulting from a temperature rise mentioned already, or a by-product]. Therefore, it becomes possible like the example mentioned already to raise the endurance of a reforming machine greatly.

[0128] Moreover, although [the reforming machines 110 and 110A of the example mentioned already] it has the reaction section constituted by the honeycomb, they are good also as a configuration which fills up the interior of a reforming machine with the pellet which supported the catalyst. Also in this case, the same effect by making controllable the oxygen density in the mixed air supplied to a reforming machine as a source of oxygen which oxidation reaction takes can be acquired.

[0129] It is also possible to prevent changing the field which heat produces and temperature rising too much locally by enabling modification of the field where oxidation reaction advances actively, and the field where advance of oxidation reaction is inactive in the interior of the catalyst section, although it was made a rapid temperature rise not happen by the upstream in the 3rd and 4th examples of the above by suppressing the activity of the oxidation reaction which advances by the upstream of a reforming machine. the entry section in which original fuel gas and oxygen are introduced into below as such a configuration, and hydrogen -- the outlet section by which rich fuel gas is discharged explains a switchable reforming machine as the 5th example.

[0130] Drawing 17 is explanatory drawing which expresses the configuration of the reforming machine 120 of the 5th example typically. The fuel cell equipment 20 of drawing 1 and the fuel cell equipment of the same configuration are equipped with this reforming machine 120. As shown in drawing 17, the reforming machine 120 is equipped with the single reaction section 121 constituted by the honeycomb which supports a Cu-Zn catalyst on the surface. This reaction section 121 is equipped with the temperature sensor 122 and temperature sensor 123 which measure the internal temperature of those both ends. These temperature sensors are connected to the control section 50 mentioned already, and the information about the internal temperature in the both ends of the reaction section 121 is inputted into a control section 50.

[0131] Moreover, in this example, the 2nd fuel-supply way 64 has branched to the 1st supply fork road 124 and the 2nd supply fork road 125, and connects each fork road to each edge of the reforming machine 120. Here, it connects with the above-mentioned 1st supply fork road 124, and also the end of the reforming machine 120 is connected with the 1st discharge fork road 126. Moreover, it connects with the above-mentioned 2nd supply fork road 125, and also the other end of the reforming machine 120 is connected with the 2nd discharge fork road 127. These 1st discharge fork roads 126 and 2nd discharge fork roads 127 join, turn into the 3rd fuel-supply way 65, and are connected to CO reduction section 36. Furthermore, solenoid valves 128,129,128A and 129A are formed in the above-mentioned 1st supply fork road 124, the 2nd supply fork road 125, the 1st discharge fork road 126, and the 2nd discharge fork road 127, respectively. These solenoid valves 128,129,128A and 129A are connected to the control section 50, and the switching condition is controlled by the control section 50.

[0132] With such a reforming vessel 120, the switching condition of the above-mentioned solenoid valve usually turns into the 1st condition that solenoid valves 128 and 128A will be in an open condition, and solenoid valves 129 and 129A will be in a closed state, or the 2nd condition that solenoid valves 129 and 129A will be in an open condition, and solenoid valves 128 and 128A will be in a closed state. When the switching condition of a solenoid valve will be in the 1st condition of the above, the original fuel gas supplied from the 2nd fuel-supply way 64 is passed toward right-hand side from the left-hand side in drawing 13 in the reaction section 121. Moreover, when the switching condition of a solenoid valve will be in the 2nd condition of the above, original fuel gas is passed toward left-hand side from the right-hand side in drawing 13 in the reaction section 121.

[0133] Drawing 18 is a flow chart showing the gas entry change manipulation routine performed with fuel cell equipment 20, in case the change of the entry section of gas which was described above in the reforming machine 120 is performed. In fuel cell equipment 20, this routine will be performed for every predetermined time amount, if starting of

fuel cell equipment 20 is directed by operating the predetermined start switch which is not illustrated.

[0134] If this routine is performed, CPU54 will judge first whether the switching condition of a solenoid valve is in the 1st condition from the switching condition of each solenoid valve mentioned already (step S300). Internal temperature T1 in the edge of the upstream to which gas is supplied when it is judged that it is in the 1st condition It reads from a temperature sensor 122 (step S310). Next, this internal temperature T1 Predetermined reference temperature T0 set up beforehand It compares (step S320). Here, it is the predetermined reference temperature T0. The internal temperature of the reaction section 121 is the value made to memorize in a control section 50 beforehand as a temperature used as the criteria which show that a temperature up is changed into the condition of not wanting, and was set as 300 degrees C by this example. It sets to step S320 and is the internal temperature T1. Reference temperature T0 When having not reached, they are return and the internal temperature T1 to step S310. Reference temperature T0 Reading of the above-mentioned internal temperature and comparative actuation are repeated until it reaches.

[0135] It sets to step S320 and is the internal temperature T1. Reference temperature T0 While making all solenoid valves into a closed state if it is judged that it is above next, measurement of elapsed time t is started with the predetermined timer with which the control section 50 was equipped and which it does not illustrate (step S330). By making all valves into a closed state in step S330, it is stopped by receipts and payments of the gas in the reforming machine 120, and the steam-reforming reaction and oxidation reaction using the original fuel gas which remains are continued as it is within the reaction section 121. Next, the predetermined conventional time t0 which set up elapsed time t beforehand It compares (step S340). Here, it is the predetermined conventional time t0. As described above, when all the valves were made into a closed state, it is the value made to memorize in a control section 50 beforehand as time amount taken to complete the steam-reforming reaction and oxidation reaction using the original fuel gas which remains to the reforming machine 120 interior, and was set as 1sec in this example. It sets to step S340 and elapsed time t is the conventional time t0. When having not reached, it is the conventional time t0. Actuation of step S340 is repeated until it passes. It sets to step S340 and elapsed time t is the conventional time t0. When it reaches, a driving signal is outputted to a predetermined solenoid valve, the switching condition of a solenoid valve is changed into the 2nd condition (step S350), and this routine is ended.

[0136] Moreover, it is the internal temperature T2 in the edge of the upstream to which it is judged that the reforming machine 120 is in the 2nd condition when it is judged in step S300 that it is not in the 1st condition, and gas is supplied. It reads from a temperature sensor 123 (step S360). After that, the same processing even as step S320 mentioned already to step S370 - step S390 - step S340 is performed. That is, it is the internal temperature T2 in advance of oxidation reaction. If the predetermined reference value T0 (this example 300 degrees C) is reached, all valves will be made into a closed state predetermined time (this example 1 sec), the switching condition of a solenoid valve will be changed into the 1st condition after that (step S400), and this routine will be ended.

[0137] in addition, the above-mentioned gas entry change manipulation routine, although it performs for every predetermined time, when starting of fuel cell equipment 20 was directed by operating the predetermined start switch which is not a drawing example, as mentioned already What is necessary is just to make it the switching condition of each solenoid valve be in the 1st above-mentioned condition or the 2nd above-mentioned condition as first condition that starting of fuel cell equipment 20 was directed. For example, in the same condition as the time of suspending fuel cell equipment 20 to last time, it is good for next time also as putting fuel cell equipment 20 into operation, and at the time of starting of fuel cell equipment 20, you may set up so that the switching condition of each solenoid valve may be in the 1st condition of the above, or the 2nd condition.

[0138] Since according to fuel cell equipment equipped with the reforming machine 120 of the 5th example constituted as mentioned above the supply part in the mixed air supplied to the reforming machine 120 can be changed by the upstream and the downstream and the flow direction of the gas in the reaction section 121 can be reversed, only one edge of a reforming machine does not carry out a temperature up too much with the heat produced in oxidation reaction. Therefore, the rapid temperature rise in the upstream can be suppressed. Here, in order to perform the change of the flow direction of gas based on the temperature of the edge of the reaction section 121, it becomes possible about the temperature of the edge of the reaction section 121 rising too much to protect more certainly.

[0139] Moreover, since the both ends of the reaction section 121 can serve as the upstream by changing the flow direction of gas as described above, temperature does not fall too much by the specific downstream like the conventional reforming machine. Therefore, with the reforming vessel 120, it is maintained at the condition that the activity of a steam-reforming reaction is high, on the both sides, and while fully being able to use the catalyst with which the reaction section 121 whole is equipped, the speed of a steam-reforming reaction can be raised. Therefore, it becomes possible to use a reforming machine as a compact more.

[0140] It is explanatory drawing which drawing 19 stuck with the reforming machine known conventionally [with the

fixed flow direction of internal gas], and the reforming machine 120 mentioned above, and expressed the temperature-distribution condition inside [from an end side] an other end side. Since it is stopped unlike the conventional reforming machine that oxidation reaction advances too much to a specific edge side and a both-ends side can turn into the upstream, the reforming machine 120 can equalize the internal temperature of a reforming machine in a 250-300-degree C temperature requirement. As explained above, since temperature does not rise rapidly near [the] the entry section, the reforming machine 120 of this example can prevent un-arranging [which it is called generating of the catalyst deactivation resulting from a temperature rise mentioned already, or a by-product]. Therefore, it becomes possible like the example mentioned already to raise the endurance of a reforming machine greatly.

[0141] In addition, although [the reforming machine 120 of this example] it has the reaction section constituted by the honeycomb, it is good also as a configuration which fills up the interior of a reforming machine with the pellet which supported the catalyst. Also in this case, the same effect by changing the flow direction of the gas which passes reforming circles can be acquired.

[0142] Moreover, based on the temperature of the edge of the reaction section 121 although [the reforming machine 120 of this example] the flow direction of gas is changed, its timing of a change is good also as being based on other factors. Although there is an advantage that a high effect is acquired when maintaining internal temperature within the limits of predetermined also when changing the amount of the original fuel gas supplied to the reforming machine 120 when based on the edge temperature of the reaction section 121 and changing the amount of the steam-reforming reaction and oxidation reaction which advance in the reforming machine 120 interior For example, when fluctuation of the amount of original fuel gas supplied to a reforming machine is small, it is good also as changing the flow direction of gas for every predetermined time amount.

[0143] Next, by agitating the catalyst particle enclosed with the interior of a reforming machine as the 6th example shows the configuration which prevents only the specific upstream in a reforming machine carrying out a temperature up too much. Drawing 20 is explanatory drawing which expresses typically the configuration of the member connected with the reforming machine 130 of the 6th example, and this reforming machine 130. Since the fuel cell equipment 20 of drawing 1 and the fuel cell equipment of the same configuration are equipped with the reforming machine 130 of this example, in the following explanation, it attaches the member number same about a common member, and omits detailed explanation.

[0144] The reforming machine 130 is enclosed with the interior in the particle which consists of a Cu-Zn catalyst mentioned already. This catalyst corns the Cu-Zn catalyst produced with the well-known coprecipitation method so that it may become the particle size of about 500 micrometers. Or it is good also as producing the particle of the particle size described above by supplying and spraying a Cu-Zn catalyst on spray dryer equipment after distributing a predetermined solvent. Moreover, in case the particle size of a catalyst particle injects gas in the reforming machine which encloses this catalyst particle so that it may mention above, it is [that what is necessary is just the magnitude in which it is fully agitated and deals by this gas] desirable [particle size] to consider as the particle size of 100 micrometers - several mm. Moreover, although the configuration of a catalyst particle may be what kind of thing, considering the effectiveness of churning mentioned later, the spherically nearer one is desirable.

[0145] Like the example mentioned already, although air is supplied from a blower 38 while the original fuel gas which consists of a methanol and a steam is supplied from an evaporator 32, by this example, such original fuel gas and air are supplied in the reforming machine 130 through a pressure regulating valve 132 and an injection nozzle 134 by the reforming machine 130. With an evaporator 32, original fuel gas is discharged in the condition that a methanol and water have a predetermined temperature and a predetermined pressure from an evaporator 32 since a temperature up is carried out, evaporation and. This original fuel gas is injected in the reforming machine 130 through a pressure regulating valve 132 and an injection nozzle 134, after being mixed with the air supplied from the air supply way 39. By injecting the original fuel gas containing air, since the catalyst particle is enclosed in the reforming machine 130 as described above, within the reforming machine 130, it flows and a catalyst particle is agitated, as the drawing 20 Nakaya mark shows. Although [here / the reforming machine 130 of this example] injection of the original fuel containing air is performed from seven places, if churning is fully possible in a catalyst particle within a reforming machine, the number of injection parts is good also as a different configuration. Moreover, the capacity of the reforming machine 130 interior should just be the magnitude by which the catalyst particle of the specified quantity may fully be agitated by the gas (original fuel gas containing oxygen) supplied by the predetermined flow rate and the predetermined pressure.

[0146] In the reforming machine 130, the filter 136 formed with foaming nickel is formed in the edge which an injection nozzle connects, and the edge of the opposite side. Although it bars this filter 136 that the catalyst particle enclosed in the reforming machine 130 leaks outside since it is fully formed in the shape of [of an eye] a fine mesh, it does not bar

it that the fuel gas generated within the reforming machine 130 is supplied to CO reduction section 36 side. The fuel gas which passed the filter 136 is supplied to a fuel cell 40, after CO reduction section 36 is supplied and carbon monoxide concentration is reduced.

[0147] Since the catalyst particle which was enclosed in the reforming machine 130 according to fuel cell equipment equipped with the reforming machine 130 constituted as mentioned above is always agitated by the original fuel gas containing air, only the specific field of a catalyst does not carry out the temperature up of it too much with the heat which the catalyst particle which exists in the location to which the original fuel gas containing high-concentration oxygen is supplied always interchanges, and produces in oxidation reaction. Here, since the gas injected in a reforming machine in order to agitate a catalyst particle is gas (original fuel gas containing air) for presenting the steam-reforming reaction and oxidation reaction which advance within a reforming machine, it can perform to coincidence actuation which supplies a original fuel to the reforming machine 130, and actuation which agitates a catalyst particle. Moreover, the electrochemical reaction in the reaction or fuel cell in a reforming machine is not influenced by injecting gas in a reforming machine.

[0148] Moreover, since the heat produced in oxidation reaction is also distributed by churning of the catalyst particle in the reforming machine 130 in the reforming machine 130, temperature does not fall too much by the specific downstream like the conventional reforming machine. Therefore, with the reforming vessel 130, it is maintained at the condition that the activity of a steam-reforming reaction is high, in the whole catalyst particle, and the speed of a steam-reforming reaction can be raised.

[0149] Drawing 21 is explanatory drawing which expressed the temperature-distribution condition inside [from an end side] an other end side about the reforming machine known conventionally [with the fixed flow direction of internal gas], and the reforming machine 130 mentioned above. Here, the gas supplied to the reforming machine 130 mixed the original fuel gas of the temperature of 250 degrees C, and flow rate 670 l/min, and the air of flow rate 140 l/min, and injected them in the reforming machine 130 from the injection nozzle 134 with five atmospheric pressures. Since unlike the conventional reforming machine oxidation reaction does not advance too much to a specific edge side and an internal catalyst particle is concerned with a reaction in the equal condition, the reforming machine 130 can equalize the internal temperature of a reforming machine in a 250-300-degree C temperature requirement. As explained above, since temperature does not rise rapidly near [the] the entry section, the reforming machine 130 of this example can prevent un-arranging [which it is called generating of the catalyst de-activation resulting from a temperature rise mentioned already, or a by-product]. Therefore, it becomes possible like the example mentioned already to raise the endurance of a reforming machine greatly.

[0150] In addition, although the original fuel gas containing air was used in the 6th example of the above as gas injected in the reforming machine 130 for churning, it is good also as using the gas which consists of any one at least among methanol gas, a steam, and air. In this case, what is necessary is just to suppose that the remaining components which were not used for injecting in a reforming machine for churning of a catalyst are supplied maintaining the condition that the catalyst particle was enclosed, to the inside of a reforming machine from the position (it is desirable that it is the upstream near the above-mentioned injection location) of a reforming machine.

[0151] Moreover, although the catalyst particle enclosed in the reforming machine 130 by injecting high-pressure gas in the reforming machine 130 is agitated in the 6th example of the above, it is good also as agitating a catalyst particle with means other than injection of gas. For example, it is good also as establishing the mechanical means which can agitate an internal catalyst particle in a reforming machine.

[0152] Next, the configuration to which the part to which the air with which oxidation reaction is presented is supplied is changed with time in the catalyst section as the 7th example is shown. Drawing 22 is explanatory drawing showing the configuration of the reforming machine 140 of the 7th example typically. The fuel cell equipment 20 of drawing 1 and the fuel cell equipment of the same configuration are equipped with this reforming machine 140. As shown in drawing 22, the reforming machine 140 equips the surface with the single reaction section 141 constituted by the honeycomb which supports a Cu-Zn catalyst, and is formed in it in the shape of a cylindrical shape. Moreover, the reforming machine 140 is pivotable by the predetermined motor which is not illustrated. Here, although the reforming machine 140 discharges the generated fuel gas to the 3rd fuel-supply way 65 like the example mentioned already while original fuel gas is supplied from the 2nd fuel-supply way 64, it has connected these 2nd fuel-supply way 64 and the 3rd fuel-supply way 65 to the abbreviation core of the cross section which carried out the approximate circle form of the reforming machine 140. By driving the above-mentioned motor, the reforming machine 140 rotates at the rate of per second 1 rotation centering on the core of the above-mentioned cross section.

[0153] Moreover, although air is supplied to it from the air supply way 39 while original fuel gas is supplied to the reforming machine 140 from the 2nd fuel-supply way 64, in this example, the edge by the side of connection with the

reforming machine 140 in this air supply way 39 is formed in the 2nd fuel-supply way 64. The edge of the air supply way 39 formed in the 2nd fuel-supply way 64 curves in the space established in the upstream of the reaction section 141 in the reforming machine 140, and is carrying out the opening as a diffuser 142 after that. This diffuser 142 meets the edge of the upstream of the reaction section 141, is carrying out the opening, and made that location that carries out a opening near middle with the circumference section of an edge cross section as well as the central point of the edge cross section of the reaction section 141 by this example. Air can be supplied to the cel of an abbreviation moiety focusing on the cel which is all over a diffuser 142 among each cel of the honeycomb which constitutes the reaction section 141 by blowing off the air supplied from the air supply way 39 from this diffuser 142.

[0154] Therefore, if the reforming machine 140 of this example is used, in the cel which receives supply of air from a diffuser 142, both a steam-reforming reaction and oxidation reaction will advance, and only a steam-reforming reaction will advance in the cel which does not receive supply of air. It rotates, as the reforming machine 140 was mentioned already at this time, and in order not to concern the location of a diffuser 142 with the condition of rotation of the reforming machine 140 and not to change, the cel which receives supply of air changes with time.

[0155] Since the cel which advances oxidation reaction in response to supply of air changes with time according to the reforming machine 140 of the 7th example constituted as mentioned above, in the upper section of a specific cel, temperature does not rise too much. Oxidation reaction advances in response to supply of air, in the cel in which the upstream cut only the temperature up, it will be in the condition of not receiving supply of air immediately, and oxidation reaction stops, and since the produced heat is consumed at a steam-reforming reaction, temperature does not rise any more. Moreover, in the cel in which heat was consumed by the steam reaction, without receiving supply of air, since air is supplied immediately and heat arises by oxidation reaction, temperature does not fall too much.

[0156] In addition, in the reforming machine 140, since the ratio of the amount of methanols and air content which are supplied becomes settled from the example mentioned already, the quantity of heat which the steam-reforming reaction which advances within a reforming machine takes similarly, and the quantity of heat produced in oxidation reaction, it is fixed. Here, with the reforming vessel 140 of this example, the cel which receives supply of air is always the abbreviation one half of the whole cel which constitutes a honeycomb. Therefore, in case each cel receives supply of air, the oxidation reaction which produces the heat more than the heat which takes the methanol which a superfluous quantity of oxygen will be supplied and was supplied rather than usual to carry out steam reforming occurs to the amount of methanols. However, as mentioned above, since supply of air is suspended immediately, as for these cels, temperature does not rise too much by the upstream to which air was supplied. Moreover, since air and original fuel gas are supplied in the condition with superfluous oxygen, the field where oxidation reaction occurs spreads even in the downstream more from the case where the oxygen of the usual concentration is supplied. Therefore, temperature does not fall too much by the downstream like the conventional reforming machine. Thus, with the reforming vessel 140, while maintaining the whole reaction section at a predetermined temperature requirement and maintaining the activity of a steam-reforming reaction at a high condition, the speed of a steam-reforming reaction can be raised.

[0157] Drawing 23 is explanatory drawing which took lessons from the whole cel which constitutes a honeycomb with the reforming machine known conventionally always supplies the oxygen of a predetermined rate, and the reforming machine 140 mentioned above, and expressed the temperature-distribution condition inside [from the upstream] the downstream with it. Measurement of this temperature-distribution condition was performed in the gas supplied to the reforming machine 140 in the conditions containing the air from which the ratio of LHSV(methanol volume / catalyst volume processed in 1 hour) = 3, and an oxygen/methanol becomes 11%, and the water with which the ratio of water/methanol is set to 2. Unlike the conventional reforming machine, temperature does not rise too much by the upstream and the reforming machine 140 can equalize the internal temperature of a reforming machine in a 250-300-degree C temperature requirement. Therefore, the reforming machine 140 of this example can prevent un-arranging [which it is called generating of the catalyst de-activation resulting from a temperature rise mentioned already or a by-product], and it becomes possible like the example mentioned already to raise the endurance of a reforming machine of it greatly. In addition, when fuel gas was generated using the reforming machine 140 in the above-mentioned conditions, $2 = 23\%$ of COs, and $H_2O = 17.5\%$, $2 = 9\%$ of N and the fuel gas used as $CO = 0.5\%$ were obtained, and operating good was confirmed $H_2 = 50\%$.

[0158] Although the reforming machine 140 of the 7th example explained above was considered as the configuration which the diffuser 142 with which air is supplied is fixed and the reforming machine 140 rotates, a diffuser can rotate and it can also be considered as the configuration to which the reforming machine was fixed. Such a reforming machine of a configuration is shown below as a modification of the 7th example. Drawing 24 is explanatory drawing which expresses typically the configuration of reforming machine 140A which is the modification of the 7th example. Reforming machine 140A is equipped with the almost same configuration as the reforming machine 140, and attaches

and explains Sign A to the same number at a corresponding member. Reforming machine 140A does not rotate in this reforming machine 140A. Moreover, the predetermined rolling mechanism 144 is formed in the bend which was prepared in the edge side which results in diffuser 142A in the air supply way 39 and which was mentioned already. By this rolling mechanism 144, the edge of the air supply way 39 equipped with diffuser 142A is rotated, and the field to which air is supplied from diffuser 142A changes with time in the upstream edge side of reaction section 141A.

[0159] Thus, also when using constituted reforming machine 140A, the same effect as the reforming machine 140 of the 7th example can be done so. In addition, the rolling mechanism 144 established near the edge of the air supply way 39 is considered as the configuration supported for the edge member 143 equipped with diffuser 142A, and the base of the air supply way 39, enabling free rotation, and the above-mentioned edge member 143 is good also as rotating according to the reaction force to which air blows off from diffuser 142A, and it is good also as generating turning effort using the predetermined power supplied from the outside.

[0160] In addition, what is necessary is to prepare two or more air supply openings in the upper section of a reforming machine, to be able to be good also as a configuration which changes with time air supply opening with which air is actually supplied, and just to be able to change with time the part to which air is supplied in the reaction section, although carried out to rotating either the diffuser of air or the reforming machines in the above-mentioned example. Moreover, although [the above-mentioned reforming machine 140 and reforming machine 140A] it has the reaction section constituted by the honeycomb, each reaction section may be constituted by being filled up with the pellet which supports a catalyst. Also in this case, the same effect as an example can be acquired by changing with time the part to which air is supplied in the reaction section.

[0161]

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] This invention relates to the fuel reformer which generates hydrogen-rich gas from a hydrocarbon and a steam in detail about a fuel reformer.

[0002]

[Description of the Prior Art] The fuel reformer which generates hydrogen-rich gas from a hydrocarbon and a steam is known as equipment for supplying fuel gas to a fuel cell. A fuel cell is equipment which changes into direct electrical energy the chemical energy which a fuel has, without going via mechanical energy or heat energy, and can realize high energy efficiency. The fuel gas containing hydrogen is supplied to such a fuel cell at a cathode side, and the oxidation gas containing oxygen is supplied to it at an anode plate side, and it acquires electromotive force according to the electrochemical reaction which occurs on two poles. The formula showing the electrochemical reaction which occurs in below with a fuel cell is shown. (1) A formula expresses the reaction by the side of cathode, and the reaction by the side of an anode plate of (2) types, and the reaction shown in (3) types advances in the whole fuel cell.

[0003]

$H_2 \rightarrow 2H^{++} + 2e^-$ -- (1)

$(1/2) O_2 + 2H^{++} + 2e^- \rightarrow H_2O$ -- (2)

$H_2 + (1/2) O_2 \rightarrow H_2O$ -- (3)

[0004] It is possible to use the oxidation gas containing a carbon dioxide and fuel gas from the property of the electrolyte among various fuel cells with a polymer electrolyte fuel cell, a phosphoric acid fuel cell, and a molten carbonate electrolyte fuel cell. Then, with these fuel cells, the hydrogen-rich gas which carried out steam reforming of the hydrocarbons, such as a methanol and natural gas, and generated them is usually used as fuel gas, using air as oxidation gas. Therefore, the above-mentioned fuel reformer is prepared in the fuel cell system equipped with such a fuel cell, a steam-reforming reaction is performed in this fuel reformer, and fuel gas is generated. Below, the reforming reaction which advances inside a fuel reformer is explained. Here, the case where a methanol is used as a hydrocarbon with which a reforming reaction is presented is explained. The formula showing the reaction which carries out steam reforming of the methanol to below is shown.

[0005]

$CH_3OH + H_2O \rightarrow CO_2 + 3H_2 - 49.5 \text{ (kJ/mol)}$ -- (4)

[0006] As shown in the above-mentioned (4) formula, since a steam-reforming reaction is endothermic reaction, in order to advance a reforming reaction, it needs to supply heat energy. The method of forming a burner, a heater, etc. in a fuel reformer and performing heat tracing as a method of supplying the heat energy which a reforming reaction takes, the method of advancing a steam-reforming reaction using the heat which is made to perform the oxidation reaction which is exothermic reaction in addition to a steam-reforming reaction, and is produced in oxidation reaction in the interior of a fuel reformer, etc. are learned. Among these methods, how to advance oxidation reaction with a steam-reforming reaction inside a fuel reformer is explained.

[0007]

$CH_3OH + (1/2) O_2 \rightarrow CO_2 + 2H_2 + 189.5 \text{ (kJ/mol)}$ -- (5)

[0008] The above-mentioned (5) formula expresses an example (partial oxidation reaction) of oxidation reaction of a methanol. Oxygen is supplied to the fuel reformer which performs a steam-reforming reaction, and if a methanol is made to oxidize with the steam-reforming reaction expressed to (4) types, the heat energy produced in oxidation reaction can be used in a steam-reforming reaction. If the amount of oxygen supplied to a fuel reformer is adjusted here, the quantity of heat which a steam-reforming reaction takes, and the quantity of heat produced in oxidation reaction can

be balanced, and it will also become possible to provide meals with the quantity of heat which produces theoretically all the quantity of heat that a steam-reforming reaction takes in oxidation reaction. The method of providing with the quantity of heat which produces the quantity of heat which such a steam-reforming reaction takes in oxidation reaction can reduce the amount of energy lost by thermolysis compared with the method of performing heat tracing mentioned already, and can realize higher energy efficiency. Furthermore, compared with the method of performing heat tracing, the configuration of a fuel reformer can be simplified and the whole system can be miniaturized.

[0009]

[Problem(s) to be Solved by the Invention] However, the above-mentioned method of using the heat energy which supplied oxygen with the methanol and the steam to the fuel reformer, and was produced by oxidation reaction at a steam-reforming reaction had the problem that the distribution condition of temperature will become an ununiformity, in the interior of a fuel reformer. Drawing 38 is explanatory drawing showing the situation of the temperature distribution in the interior of a fuel reformer when supplying oxygen to a fuel reformer with a methanol and a steam, and oxidizing with a steam-reforming reaction. If oxygen is introduced with a methanol and a steam to a fuel reformer, since the reaction rate of oxidation reaction is quicker than a steam-reforming reaction, as the quantity of heat produced in oxidation reaction exceeds the quantity of heat which a steam reaction takes and it is shown in drawing 38, by the upstream (side which introduces the gas containing a methanol, a steam, and oxygen) in a fuel reformer, internal temperature will rise rapidly and the peak of temperature distribution will be formed. Moreover, in order only for a steam-reforming reaction to advance after oxygen is consumed by oxidation reaction, as for after the peak of the above-mentioned temperature distribution, the internal temperature of a fuel reformer continues descent toward the downstream (side by which hydeogen-rich gas is discharged).

[0010] When temperature distribution form a peak inside a fuel reformer and temperature rises too much, a catalyst deteriorates or problems, like a by-product arises are produced. First, deterioration of a catalyst is explained. For example, in using a Cu-Zn catalyst as a catalyst which promotes the steam-reforming reaction and oxidation reaction of a methanol, when it uses this Cu-Zn catalyst under the elevated temperature exceeding 300 degrees C, the endurance of a catalyst falls and there is a possibility of causing and carrying out sintering. Sintering means the phenomenon which the catalyst supported by the carrier surface condenses here. Although the Cu-Zn catalyst is usually carrying out the configuration to which copper particles are scattered on the surface of a zinc particle, if sintering is caused, a copper particle will condense and a particle will grow large. If such a phenomenon arises, since the activity area of a catalyst decreases with the fall of the surface area of a copper particle, the engine performance of a fuel reformer will fall.

[0011] Moreover, reactions other than the normal reaction for which generating of the by-product which is another problem by whenever [catalyst temperature] going up too much mentioned already when a reforming reaction advanced under a predetermined elevated temperature occur, and it says that methane arises, or the nitrogen gas in the supplied pressurization air reacts, and nitrogen oxides arise. In the range of the reforming reaction temperature in a fuel reformer, it is not decomposed and these by-products will be supplied to a fuel cell as fuel gas as they are. Especially the thing that the amounts of generation, such as methane, increase leads to the fall of the hydrogen partial pressure in fuel gas and is not desirable.

[0012] On the other hand, if internal temperature falls in the downstream of a fuel reformer, the problem that the activity of a steam-reforming reaction falls with the fall of temperature will be produced. When the activity of a steam-reforming reaction falls, there is gas which has not completed a reforming reaction, i.e., a possibility that a methanol may remain and gas with inadequate hydrogen concentration may be generated. Or even if internal temperature falls by the downstream, it is necessary to have a fuel reformer big enough so that a reforming reaction may be completed.

[0013] The fuel reformer of this invention solved such a problem, was made for the purpose of equalizing the internal temperature of a fuel reformer in a predetermined temperature requirement, and took the next configuration.

[0014]

[The means for solving a technical problem, and its operation and effect] The steam-reforming reaction which the 1st fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon, steam, and oxygen to said catalyst section, In a fuel gas discharge means to discharge rich fuel gas from said catalyst section, and said catalyst section the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- Let it be a summary to have the gas flow rate accommodation means which makes quick the rate of flow of said Hara fuel gas in the portion of the side into

which said Hara fuel gas is introduced so that the heat produced in said oxidation reaction which occurs in the portion of the side to which said Hara fuel gas is supplied may fully be carried to the downstream.

[0015] If the original fuel gas containing a hydrocarbon, a steam, and oxygen is supplied to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, in this catalyst section, the 1st fuel reformer of this invention constituted as mentioned above will be a reaction accompanied by an endothermic, and will advance the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon. the heat produced in said oxidation reaction at this time -- using -- said steam-reforming reaction -- going on -- hydrogen -- rich fuel gas is generated and it is discharged from said catalyst section. Here, in the catalyst section, the rate of flow of said Hara fuel gas in the portion of the side into which said Hara fuel gas is introduced is adjusted so that the heat produced in said oxidation reaction which occurs in the portion of the side to which said Hara fuel gas is supplied may fully be carried to the downstream.

[0016] Since the heat produced by the oxidation reaction which occurs in the portion of the side into which said Hara fuel gas is introduced is fully carried to the downstream according to such a fuel reformer, in the portion of the side into which said Hara fuel gas is introduced, temperature does not rise too much. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly. Furthermore, by fully carrying the heat produced in oxidation reaction to the downstream, in the downstream, activity of a steam-reforming reaction can be made high enough, and it becomes possible to miniaturize a fuel reformer.

[0017] After the hydrocarbon, the steam, and oxygen which constitute original fuel gas mix all beforehand, it is not necessary to supply them here, and a part of at least one component or original fuel gas is good also as supplying separately. Even if it does not mix beforehand, the effect described above when these components that constitute original fuel gas were supplied from the upstream of the flow direction of the gas in the catalyst section can be acquired. Moreover, the catalyst which promotes a steam-reforming reaction, and the catalyst which promotes oxidation reaction may be the same, and you may differ. That is, a steam-reforming reaction and oxidation reaction are good also as both reactions being promoted by the single catalyst, and it is good also as each reaction being promoted by different catalyst. When using a different catalyst, it is desirable to fully mix both within a reforming machine.

[0018] In the 1st fuel reformer of above-mentioned this invention, said gas flow rate accommodation means is better than the side by which said fuel gas is discharged at the side to which said Hara fuel gas in said catalyst section is supplied also as coming it small to carry out the gross area of the cross section of the passage where said Hara fuel gas flows. By considering as such a configuration, the rate of flow of said Hara fuel gas in that of the side to which said Hara fuel gas is supplied can be made quicker than the side by which said fuel gas is discharged, and the above-mentioned effect can be acquired.

[0019] The steam-reforming reaction which the 2nd fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon, steam, and oxygen to said catalyst section, the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- rich fuel gas Having a fuel gas discharge means to discharge from said catalyst section, said catalyst in said catalyst section makes it a summary to be held at the catalyst support formed with a thermally conductive, comparatively high material.

[0020] The 2nd fuel reformer of this invention constituted as mentioned above If the original fuel gas containing a hydrocarbon, a steam, and oxygen is supplied to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, it will set in this catalyst section. the hydrogen which advanced and generated the steam-reforming reaction which is a reaction accompanied by an endothermic and generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon -- rich fuel gas is discharged. Here, since said catalyst is supported by the catalyst support formed with a thermally conductive, comparatively high material, the heat produced in said oxidation reaction is promptly told to a periphery by catalyst support, and is used for said steam-reforming reaction.

[0021] Since the heat produced in oxidation reaction is spread promptly according to such a fuel reformer, it is the side to which said Hara fuel gas is supplied, and temperature does not rise too much to the side to which said oxidation reaction advances actively. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised

greatly. Furthermore, by spreading the heat produced in oxidation reaction and being told to the downstream, in the downstream, activity of a steam-reforming reaction can be made high enough, and it becomes possible to miniaturize a fuel reformer.

[0022] The steam-reforming reaction which the 3rd fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction, and the catalyst which promotes said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon and steam to said catalyst section, An oxidation gas supply means to supply the oxidation gas containing oxygen to said catalyst section, In the side into which a fuel gas discharge means to discharge rich fuel gas from said catalyst section, and said oxidation gas in said catalyst section are introduced the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- Let it be a summary to have an oxidation reaction control means to control advance of said oxidation reaction.

[0023] If the original fuel gas containing a hydrocarbon and a steam and the oxidation gas containing oxygen supply to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, the 3rd fuel reformer of this invention constituted as mentioned above is a reaction accompanied by an endothermic, and will advance the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon in this catalyst section. the heat produced in said oxidation reaction at this time -- using -- said steam-reforming reaction -- going on -- hydrogen -- rich fuel gas is generated and it is discharged from said catalyst section. Here, in the catalyst section, advance of said oxidation reaction is controlled at the side into which said oxidation gas is introduced.

[0024] Since advance of said oxidation reaction is controlled at the side into which said oxidation gas is introduced according to such a fuel reformer, temperature does not rise too much to the side into which said this oxidation gas is introduced. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly. Furthermore, by controlling advance of oxidation reaction by the side into which said oxidation gas is introduced, the field where oxidation reaction advances raises the temperature of the downstream by breadth and this to the downstream more, and can make activity of a steam-reforming reaction high enough. Therefore, it becomes possible to miniaturize a fuel reformer.

[0025] In the 3rd fuel reformer of above-mentioned this invention, said oxidation reaction control means is good in said catalyst section also as forming and becoming so that the amount of the catalyst for which the side into which said oxidation gas is introduced promotes said oxidation reaction rather than the side by which said fuel gas is discharged may serve as smallness.

[0026] Moreover, in the 3rd fuel reformer of this invention, the catalyst which promotes said steam-reforming reaction, and the catalyst which promotes said oxidation reaction are the same catalysts, and said oxidation reaction control means is good also as forming and consisting of a side by which said fuel gas is discharged for the direction of the side into which said oxidation gas is introduced so that the amount of said catalyst may serve as smallness.

[0027] The steam-reforming reaction which the 4th fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction, and the catalyst which promotes said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon and steam to said catalyst section, An oxidation gas supply means to supply the oxidation gas containing oxygen to said catalyst section, the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- rich fuel gas with a fuel gas discharge means to discharge from said catalyst section It has a reaction condition detection means to detect the advance condition of the reaction which advances in said catalyst department. Said oxidation gas supply means Let it be a summary to have further an oxygen density accommodation means to control the oxygen density in said oxidation gas supplied to said catalyst section, based on the advance condition of said reaction which said reaction condition detection means detected, maintaining the amount of oxygen per [which is supplied to said catalyst section] unit time amount in a desired amount.

[0028] If the original fuel gas containing a hydrocarbon and a steam and the oxidation gas containing oxygen supply to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, the

4th fuel reformer of this invention constituted as mentioned above is a reaction accompanied by an endothermic, and will advance the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon in this catalyst section. the heat produced in said oxidation reaction at this time -- using -- said steam-reforming reaction -- going on -- hydrogen -- rich fuel gas is generated and it is discharged from said catalyst section. Here, the advance condition of the reaction which advances in said catalyst department is detected, and based on the advance condition of said this detected reaction, the oxygen density in said oxidation gas supplied to said catalyst section is controlled, maintaining the amount of oxygen per [which is supplied to said catalyst section] unit time amount in a desired amount.

[0029] According to such a fuel reformer, since the oxygen density in said oxidation gas is controlled, the reaction rate of the oxidation reaction which advances to the side into which oxidation gas is introduced can be controlled, and it can prevent that temperature rises too much to the side into which said this oxidation gas is introduced. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly. Furthermore, by controlling the oxygen density in oxidation gas and controlling the reaction rate of oxidation reaction, the field where oxidation reaction advances can be extended more to the downstream, by this, the temperature of the downstream is raised and activity of a steam-reforming reaction can be made high enough. Therefore, it becomes possible to miniaturize a fuel reformer.

[0030] In the 4th fuel reformer of above-mentioned this invention, said catalyst section consists of two or more reaction sections equipped with said catalyst, and said oxidation gas supply means is good also as supplying said oxidation gas to each of two or more of said reaction sections. The effect which equalizes the temperature inside the catalyst section can be further heightened by making into plurality such a configuration, then the part to which oxidation gas is supplied.

[0031] The steam-reforming reaction which the 5th fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon, steam, and oxygen to said catalyst section, In a fuel gas discharge means to discharge rich fuel gas from said catalyst section, and said catalyst section the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- The part introduced in said Hara fuel gas from said Hara fuel gas supply means and the part which discharges said fuel gas with said fuel gas discharge means are replaced, and let it be a summary to have a direction modification means of gas supply to reverse the flow of the gas in said catalyst section.

[0032] If the original fuel gas containing a hydrocarbon, a steam, and oxygen is supplied to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, in this catalyst section, the 5th fuel reformer of this invention constituted as mentioned above will be a reaction accompanied by an endothermic, and will advance the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon. the heat produced in said oxidation reaction at this time -- using -- said steam-reforming reaction -- going on -- hydrogen -- rich fuel gas is generated and it is discharged from said catalyst section. In case such a reaction advances, in said catalyst section, the exchange with the part introduced in said Hara fuel gas and the part which discharges said fuel gas is performed.

[0033] Since the exchange with the part introduced in said Hara fuel gas and the part which discharges said fuel gas is performed in said catalyst section according to such a fuel reformer, in the specific field to which original fuel gas is introduced, temperature does not rise too much. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly. Furthermore, temperature cannot fall in the specific downstream and activity of a steam-reforming reaction can be made high enough in the whole catalyst section. Therefore, it becomes possible to miniaturize a fuel reformer.

[0034] In the 5th fuel reformer of above-mentioned this invention, it sets in said catalyst section. It has further an edge temperature detection means to detect the temperature of the near predetermined location to which said Hara fuel gas is supplied from said Hara fuel gas supply means. Said direction modification means of gas supply It is good also as replacing the part introduced in said Hara fuel gas from said Hara fuel gas supply means, and the part which discharges said fuel gas with said fuel gas discharge means based on the detection result of said edge temperature detection means. By considering as such a configuration, it can prevent certainly that temperature rises too much to the side to which original fuel gas is supplied.

[0035] The steam-reforming reaction which the 6th fuel reformer of this invention is a reaction accompanied by an

endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and comes to enclose with the interior a particle equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon, steam, and oxygen to said catalyst section, the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- let it be a summary to have a fuel gas discharge means to discharge rich fuel gas from said catalyst section, and a catalyst churning means to agitate a particle equipped with said catalyst in said catalyst department.

[0036] The 6th fuel reformer of this invention constituted as mentioned above supplies the original fuel gas containing a hydrocarbon, a steam, and oxygen to the catalyst section which comes to fill [the interior] up a particle equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction. Agitating a particle equipped with said catalyst in said catalyst section in that case, it is a reaction accompanied by an endothermic and the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon are gone on. the heat produced in said oxidation reaction at this time -- using -- said steam-reforming reaction -- going on -- hydrogen -- rich fuel gas is generated and it is discharged from said catalyst section.

[0037] In order to agitate a particle equipped with said catalyst in said catalyst section according to such a fuel reformer, the catalyst with which this particle is equipped is concerned with the sequential aforementioned oxidation reaction, and temperature does not rise too much in the specific field to which original fuel gas is introduced. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly. Furthermore, temperature cannot fall in the specific downstream and activity of a steam-reforming reaction can be made high enough in the whole catalyst section. Therefore, it becomes possible to miniaturize a fuel reformer.

[0038] In the 6th fuel reformer of above-mentioned this invention, said catalyst churning means is good also as agitating the particle which said Hara fuel gas supply means is equipped with, and sprays the gas containing at least one of said hydrocarbons, steams, and oxygen on said catalyst circles, and is equipped with said catalyst in said catalyst department. Churning can be operated to coincidence by spraying the gas which constitutes said Hara fuel to such a configuration, then said catalyst section.

[0039] The steam-reforming reaction which the 7th fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon and steam to said catalyst section, An oxidation gas supply means to supply the oxidation gas containing oxygen to said catalyst section, In a fuel gas discharge means to discharge rich fuel gas from said catalyst section, and said catalyst section the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- Let it be a summary to have a supply part modification means to change with time the part to which said oxidation gas is supplied from said oxidation gas supply means.

[0040] If the original fuel gas containing a hydrocarbon and a steam and the oxidation gas containing oxygen supply to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, the 7th fuel reformer of this invention constituted as mentioned above is a reaction accompanied by an endothermic, and will advance the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon in this catalyst section. At this time, the part to which said oxidation gas is supplied is changed with time in said catalyst section. thus, the heat produced in said oxidation reaction which advances using the supplied oxidation gas -- using -- said steam-reforming reaction -- going on -- hydrogen -- rich fuel gas is generated and it is discharged from said catalyst section.

[0041] In order for the part to which said oxidation gas is supplied to make it change with time in said catalyst section according to such a fuel reformer, in the specific field to which oxidation gas is introduced, temperature does not rise too much. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly.

[0042] The steam-reforming reaction which the 8th fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction

accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon and steam to said catalyst section, An oxidation gas supply means to supply the oxidation gas containing oxygen to said catalyst section, In a fuel gas discharge means to discharge rich fuel gas from said catalyst section, and said catalyst section the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- The discharge side by which said fuel gas is discharged the supply side to which oxidation gas is supplied with said Hara fuel gas is adjoined, and let it be a summary to have a soak-ized means to make heat exchange perform between said supply side and said discharge side.

[0043] If the original fuel gas containing a hydrocarbon and a steam and the oxidation gas containing oxygen supply to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, the 8th fuel reformer of this invention constituted as mentioned above is a reaction accompanied by an endothermic, and will advance the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon in this catalyst section. the heat which heat exchange was performed between said supply side and said discharge side, and was produced in said oxidation reaction here since said catalyst section adjoined the discharge side by which said fuel gas is discharged the supply side to which oxidation gas is supplied with said Hara fuel gas and it was formed -- using -- said steam-reforming reaction -- going on -- hydrogen -- rich fuel gas is generated and it is discharged from said catalyst section.

[0044] Since heat exchange is performed between the discharge sides by which said fuel gas is discharged in said catalyst section the supply side to which oxidation gas is supplied with said Hara fuel gas according to such a fuel reformer, in the specific field to which oxidation gas is introduced, temperature does not rise too much. Therefore, unarranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly. Furthermore, temperature cannot fall in the specific downstream and activity of a steam-reforming reaction can be made high enough in the whole catalyst section. Therefore, it becomes possible to miniaturize a fuel reformer.

[0045] In the 8th fuel reformer of above-mentioned this invention said catalyst section It is good also as equipping the interior with said catalyst respectively, having at least two or more each reaction sections of said supply which have a side and said discharge side in the location of reverse mutually, adjoining said discharge side of said feed zone of said supply side of one of said reaction section, and another side, and coming to prepare said two or more reaction sections.

[0046] Moreover, in the 8th fuel reformer of this invention, said catalyst section is good also as having the clinch section in the passage of said Hara fuel gas formed in the interior, and coming to prepare the entry section and the outlet section of said passage adjacently.

[0047] The steam-reforming reaction which the 9th fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon and steam to said catalyst section, An oxidation gas supply means to supply the oxidation gas containing oxygen to said catalyst section, the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- rich fuel gas with a fuel gas discharge means to discharge from said catalyst section Let it be a summary to have a heating means to heat portions other than the side to which said oxidation gas is supplied with the predetermined fluid which conducts the heat produced in the predetermined member which constitutes a system equipped with said fuel reformer.

[0048] If the original fuel gas containing a hydrocarbon and a steam and the oxidation gas containing oxygen supply to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, the 9th fuel reformer of this invention constituted as mentioned above is a reaction accompanied by an endothermic, and will advance the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon in this catalyst section. Here, in said catalyst section, said steam-reforming reaction advances using the heat produced in said oxidation reaction in the field in which said oxidation gas is supplied and said oxidation reaction is performed. Moreover, the heat produced in the predetermined member which constitutes a system equipped with said fuel reformer from portions other than the side to which said oxidation gas is supplied is conducted by the predetermined fluid, and said steam-reforming reaction

advances using this heat. the generated hydrogen -- rich fuel gas is discharged from said catalyst section.

[0049] According to such a fuel reformer, in portions other than the side to which said oxidation gas is supplied Since said oxidation reaction advances using the heat produced in the predetermined member which constitutes a system equipped with said fuel reformer, The amount of said oxidation gas supplied to said catalyst section can be reduced to the amount of said Hara fuel gas supplied to said catalyst section, and temperature does not rise too much to the side to which said oxidation gas is supplied. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly. Furthermore, since the heat produced in the predetermined member which constitutes a system equipped with said fuel reformer from portions other than the side to which said oxidation gas is supplied is told, when temperature falls, the activity of a steam-reforming reaction does not fall. Therefore, activity of a steam-reforming reaction can be made high enough in the whole catalyst section, and it becomes possible to miniaturize a fuel reformer. Moreover, in order to use the heat produced in the predetermined member which constitutes a system equipped with said fuel reformer, system-wide energy efficiency does not fall by heating portions other than the side to which said oxidation gas is supplied.

[0050] Moreover, in the 9th fuel reformer of above-mentioned this invention, said heating means is good also as heating portions other than the side to which said oxidation gas is supplied by the elevated-temperature gas discharged from the predetermined member which constitutes a system equipped with said fuel reformer.

[0051] The steam-reforming reaction which the 10th fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon and steam to said catalyst section, An oxidation gas supply means to supply the oxidation gas containing oxygen to said catalyst section, the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- rich fuel gas with a fuel gas discharge means to discharge from said catalyst section Let it be a summary to have an edge cooling means to spray the liquid which consists at least of one side among said hydrocarbon and water to the portion of the side supplied to said Hara fuel gas and said oxidation gas.

[0052] If the original fuel gas containing a hydrocarbon and a steam and the oxidation gas containing oxygen supply to the catalyst section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, the 10th fuel reformer of this invention constituted as mentioned above is a reaction accompanied by an endothermic, and will advance the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon in this catalyst section. Although said steam-reforming reaction advances using the heat produced in said oxidation reaction in the field in which said oxidation gas is supplied and said oxidation reaction is performed in said catalyst section here, the portion to which the fuel spray of the liquid which consists at least of one side among said hydrocarbon and water was carried out to the portion of the side to which said Hara fuel gas and said oxidation gas are supplied, and the fuel spray of said liquid was carried out is cooled at this time. the generated hydrogen -- rich fuel gas is discharged from said catalyst section.

[0053] According to such a fuel reformer, in the portion of the side to which said Hara fuel gas and said oxidation gas are supplied, since the fuel spray of the liquid which consists at least of one side among said hydrocarbon and water is carried out, a part of heat produced by said oxidation reaction is consumed as heat of vaporization, and temperature does not rise too much to the side to which said oxidation gas is supplied. Therefore, un-arranging [which it is called generating of the catalyst de-activation by temperature rising too much or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly.

[0054] The steam-reforming reaction which the 11th fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The 1st reaction section equipped with the catalyst which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and promotes said steam-reforming reaction and said oxidation reaction, The catalyst section equipped with the 2nd reaction section equipped with the catalyst which promotes said steam-reforming reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon and steam to said catalyst section, An oxidation gas supply means to supply the oxidation gas containing oxygen to said 1st reaction section, It has a fuel gas discharge means to discharge rich fuel gas from said catalyst section. the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- said catalyst section Said 1st

reaction section and said 2nd reaction section are made to adjoin, and let it be a summary to make heat exchange perform between said 1st reaction section and said 2nd reaction section.

[0055] The 11th fuel reformer of this invention constituted as mentioned above. If the original fuel gas containing a hydrocarbon and a steam and the oxidation gas containing oxygen are supplied to the 1st reaction section equipped with the catalyst which promotes a steam-reforming reaction and oxidation reaction, it will set in this 1st reaction section. It is a reaction accompanied by an endothermic and the steam-reforming reaction which generates hydrogen from a hydrocarbon and a steam, and the oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon are gone on. Moreover, if said Hara fuel gas is supplied to the 2nd reaction section equipped with the catalyst which promotes said steam reaction, said steam-reforming reaction will be gone on in this 2nd reaction section. Here, although said steam-reforming reaction advances in said 1st reaction section using the heat produced in said oxidation reaction, said steam-reforming reaction advances using the heat produced in said oxidation reaction in said 1st reaction section by carrying out heat exchange also of said 2nd reaction section to said 1st adjoining reaction section. the generated hydrogen -- rich fuel gas is discharged from said catalyst section.

[0056] In the field in which according to such a fuel reformer said oxidation gas is supplied and said oxidation reaction advances in said 1st reaction section, the heat produced by said oxidation reaction is also told to the 2nd reaction section which it is used for said steam-reforming reaction which advances in said 1st reaction section, and also adjoins, and is used also for said steam-reforming reaction which advances in this 2nd reaction section. Therefore, the temperature of said catalyst section can rise too much with the heat produced in oxidation reaction, un-arranging [which it is called generating of catalyst de-activation or a by-product] cannot arise, and the endurance of a reforming machine can be raised greatly.

[0057] Here, in the 5th of the 1st of this invention, the 2nd fuel reformer, or this invention thru/or the 10th fuel reformer, the catalyst which said hydrocarbon is a methanol and promotes said steam-reforming reaction and said oxidation reaction is good also as being a single copper system catalyst.

[0058] Moreover, in the 3rd of this invention, or the 4th fuel reformer, said hydrocarbon is a methanol and good also as the catalyst which promotes said steam-reforming reaction, and the catalyst which promotes said oxidation reaction being the same copper system catalysts.

[0059] Moreover, in the 11th fuel reformer of this invention, said hydrocarbon is a methanol and the catalyst with which said 1st reaction section is equipped is good also as being a single copper system catalyst.

[0060] In such a fuel reformer of a configuration, the steam-reforming reaction of a methanol and oxidation reaction of a methanol are promoted by the single copper system catalyst. Unlike the case where it promotes oxidation reaction using other oxidation catalysts known conventionally [, such as platinum,] in promoting oxidation reaction of a methanol according to a copper system catalyst, most advancing oxidation reaction turns into a reaction which does not produce a carbon monoxide. Therefore, fuel gas with more low carbon monoxide concentration is generable by considering as such a configuration.

[0061] The steam-reforming reaction which the 12th fuel reformer of this invention is a reaction accompanied by an endothermic, and generates hydrogen from a hydrocarbon and a steam, The oxidation reaction which is a reaction accompanied by pyrexia and oxidizes said hydrocarbon is gone on. The catalyst section which is the fuel reformer which uses the heat produced in said oxidation reaction in case said steam-reforming reaction is gone on, and is equipped with the catalyst which promotes said steam-reforming reaction and said oxidation reaction, A original fuel gas supply means to supply the original fuel gas containing said hydrocarbon, steam, and oxygen to said catalyst section, It has a fuel gas discharge means to discharge rich fuel gas from said catalyst section. the hydrogen produced as a result of said steam-reforming reaction which advances in said catalyst section, and said oxidation reaction -- said catalyst Let it be a summary to promote the reaction which does not go via the reaction path which generates a carbon monoxide as said oxidation reaction.

[0062] Since said catalyst can promote said oxidation reaction which does not go via the reaction path which generates a carbon monoxide according to such a fuel reformer, the amount of carbon monoxides produced by the reaction which advances in the catalyst department can be stopped, and fuel gas with low carbon monoxide concentration can be generated.

[0063] In the 12th fuel reformer of this invention, said hydrocarbon is a methanol and the catalyst which promotes said steam-reforming reaction and said oxidation reaction is good also as being a single copper system catalyst.

[0064] Unlike the case where oxidation reaction is promoted using other oxidation catalysts known conventionally [, such as platinum,] in order to promote oxidation reaction of a methanol according to a copper system catalyst, in such a fuel reformer of a configuration, most advancing oxidation reaction turns into a reaction which does not produce a carbon monoxide. Therefore, fuel gas with more low carbon monoxide concentration is generable by considering as

such a configuration. Moreover, since the steam-reforming reaction of a methanol and oxidation reaction of a methanol are promoted by the single copper system catalyst, the configuration of a fuel reformer can be simplified according to it.

[0065]

[Embodiment of the Invention] In order to clarify further a configuration and an operation of this invention explained above, the gestalt of operation of this invention is explained based on an example below. Drawing 1 is an outline block diagram which illustrates the configuration of fuel cell equipment 20 equipped with the reforming machine which is the 1st suitable example of this invention. a fuel cell -- equipment -- 20 -- a methanol -- storing -- a methanol -- a tank -- 22 -- water -- storing -- a water tank -- 24 -- combustion gas -- generating -- a burner -- 26 -- air -- compression -- carrying out -- a compressor -- 28 -- a burner -- 26 -- a compressor -- 28 -- having annexed -- an evaporator -- 32 -- reforming -- a reaction -- fuel gas -- generating -- reforming -- a vessel -- 34 -- fuel gas -- inside -- a carbon monoxide -- (-- CO --) -- concentration -- decreasing First, the fuel cell 40 which is the subject of the generation of electrical energy in fuel cell equipment 20 is explained.

[0066] A fuel cell 40 is a fuel cell of a solid-state polyelectrolyte mold, and has the stack structure which carried out two or more laminatings of the single cel which is a configuration unit. Drawing 2 is a cross section which illustrates the configuration of the single cel 48 which constitutes a fuel cell 40. The single cel 48 consists of an electrolyte film 41, a cathode 42 and an anode 43, and separators 44 and 45.

[0067] A cathode 42 and an anode 43 are gas diffusion electrodes which constitute sandwich structure on both sides of the electrolyte film 41 from both sides. Separators 44 and 45 form the passage of fuel gas and oxidation gas between a cathode 42 and an anode 43, sandwiching this sandwich structure from both sides further. Fuel gas passage 44P are formed between the cathode 42 and the separator 44, and oxidation gas-passageway 45P are formed between the anode 43 and the separator 45. Although separators 44 and 45 form passage only in one side in drawing 2, respectively, the rib is formed in the both sides in fact, one side forms fuel gas passage 44P between cathodes 42, and other sides form oxidation gas-passageway 45P between the anodes 43 with which the adjoining single cel is equipped. Thus, separators 44 and 45 have played the role which separates the flow of fuel gas and oxidation gas between the adjoining single cels while forming a gas passageway between gas diffusion electrodes. In case the laminating of the single cel 48 is carried out and stack structure is formed from the first, the separator of two sheets located in the both ends of stack structure is good also as forming a rib only in one side which touches a gas diffusion electrode.

[0068] Here, the electrolyte film 41 is the ion exchange membrane of proton conductivity formed by solid-state polymeric materials, for example, fluorine system resin, and shows good electrical conductivity according to a damp or wet condition. The Nafion film (Du Pont make) was used in this example. The alloy which consists of the platinum as a catalyst or platinum, and other metals is supported by the surface of the electrolyte film 41.

[0069] Both the cathode 42 and the anode 43 are formed of the carbon crossing woven with the thread which consists of a carbon fiber. In addition, a cathode 42 and an anode 43 are formed by carbon crossing, and also the configuration formed by the carbon paper which consists of a carbon fiber, or carbon felt is suitable for them.

[0070] Separators 44 and 45 are formed by the conductive gas non-penetrated member, for example, the substantia-compacta carbon which compressed carbon and it presupposed gas un-penetrating. Separators 44 and 45 form in the both sides two or more ribs arranged in parallel, and as mentioned already, fuel gas passage 44P are formed on the surface of a cathode 42, and they form oxidation gas-passageway 45P on the surface of the anode 43 of the adjoining single cel. Here, the rib formed in the surface of each separator is good also as making a predetermined angle -- it is not necessary to form both sides in parallel, and they go direct for every field. Moreover, it does not need to be an parallel groove, and if supply of fuel gas or oxidation gas is possible for the configuration of a rib to a gas diffusion electrode, it is good.

[0071] In the above, the configuration of the single cel 48 which is the basic structure of a fuel cell 40 was explained. When actually assembling as a fuel cell 40, stack structure is constituted by carrying out two or more set laminating of a separator 44, a cathode 42, the electrolyte film 41, an anode 43, and the single cel 48 constituted in order of a separator 45 (this example 100 sets), and arranging the collecting electrode plate formed in the both ends by substantia-compacta carbon, a copper plate, etc.

[0072] Hereafter, sequential explanation is given about the components and those connection relation other than fuel cell 40 which constitutes fuel cell equipment 20. An evaporator 32 is equipment which supply of a methanol and water is received [equipment] from the methanol tank 22 and a water tank 24, and makes these methanols and water evaporate. although the burner 26 and the compressor 28 are put side by side as mentioned already, the combustion gas of a burner 26 is drawn through a compressor 28 so that it may mention later, this heat of combustion is told to the heat exchanger with which an evaporator 32 is equipped and which is not a drawing example, and an evaporator 32 boils the

methanol and water which were supplied to the evaporator 32, and is made to evaporate

[0073] The 2nd pump 71 is formed in the methanol passage 60 which sends into an evaporator 32 the methanol which is a original fuel from the methanol tank 22, and the amount of methanols supplied to an evaporator 32 can be adjusted. This 2nd pump 71 is connected to the control section 50, it drives with the signal outputted from a control section 50, and the methanol flow rate supplied to an evaporator 32 is adjusted.

[0074] The 3rd pump 72 is formed in the water supply way 62 which sends water into an evaporator 32 from the water tank 24, and the amount of the water supplied to an evaporator 32 can be adjusted. This 3rd pump 72 is connected to the control section 50 as well as the 2nd pump 71, it drives with the signal outputted from a control section 50, and the amount of water supplied to an evaporator 32 is adjusted. The above-mentioned methanol passage 60 and the water supply way 62 join, the 1st fuel-supply way 63 is formed, and this 1st fuel-supply way 63 is connected to an evaporator 32. Since a methanol flow rate and amount of water are adjusted with the 2nd pump 71 of the above, and the 3rd pump 72, the methanol and water which were mixed the specified quantity every are supplied to an evaporator 32 through the 1st fuel-supply way 63.

[0075] The compressor 28 put side by side to the evaporator 32 is equipment for incorporating air from the exterior of fuel cell equipment 20, compressing this, and supplying this compressed air to the anode plate side of a fuel cell 40. A compressor 28 is equipped with turbine 28a and compressor 28b, and these are fabricated by the impeller mold. Turbine 28a and compressor 28b are connected by shaft 28c on the same axle, and can carry out the rotation drive of the compressor 28b by carrying out the rotation drive of the turbine 28a. Although the burner 26 is further put side by side to the evaporator 32, turbine 28a drives by the hot combustion gas of this burner 26. Compressor 28b also rotates with rotation of turbine 28a, and this compressor 28b compresses air, as mentioned already. To compressor 28b, the air which the incorporation of air has become possible from the exterior through the air installation way 29, and was compressed with the compressor 28 is supplied to a fuel cell 40 through the oxidation gas supply way 68, and the electrochemical reaction in a fuel cell 40 is presented with it.

[0076] Here, since turbine 28a is driven by the hot combustion gas of a burner 26, in order to realize thermal resistance and endurance, it is formed with superalloy, the ceramics, etc. In this example, the alloy (Inconel 700, Inconel company) of the nickel base was used. Moreover, compressor 28b is formed with a lightweight aluminium alloy.

[0077] The fuel for combustion is supplied to the burner 26 which drives turbine 28a from the cathode side of a fuel cell 40, and the methanol tank 22. Although a fuel cell 40 uses as a fuel the hydeogen-rich gas which reformed and generated the methanol with the reforming vessel 34 and electrochemical reaction is performed, the fuel exhaust gas containing the hydrogen which remained without not consuming all the hydrogen supplied to the fuel cell 40 in electrochemical reaction, and being consumed is discharged by the fuel exhaust passage 67. The perfect combustion of the hydrogen which it connected with this fuel exhaust passage 67, and the burner 26 received supply of fuel exhaust gas, and remained, without being consumed is carried out, and improvement in the utilization factor of a fuel is in drawing. Usually, only with such exhaust fuel, since it runs short as a fuel for the combustion reaction in a burner 26, the fuel for the combustion reaction in the burner 26 in case there is nothing a carrier eclipse about supply of exhaust fuel is supplied from the methanol tank 22 from a fuel cell 40 to a burner 26 like [at the time of starting of the fuel equivalent to this insufficiency and fuel cell equipment 20]. In order to supply a methanol to a burner 26, the methanol fork road 61 is formed. This methanol fork road 61 has branched from the methanol passage 60 which supplies a methanol to an evaporator 32 from the methanol tank 22.

[0078] Here, the 1st temperature sensor 73 is formed in the burner 26, the temperature of the heat of combustion in a burner 26 was measured, and this measurement result is inputted into the control section 50. Based on the input result from this 1st temperature sensor 73, a control section 50 outputs a driving signal to the 1st pump 70, adjusts the amount of methanols supplied to a burner 26, and is maintaining the combustion temperature in a burner 26 at the predetermined range (from about 800 degrees C to 1000 degrees C). After the combustion gas in this burner 26 carries out the rotation drive of the turbine 28a, it is led to an evaporator 32. Since the heat exchange effectiveness in turbine 28a is not not much high (less than about 10%), the temperature of the combustion gas led to an evaporator 32 amounts to about 600-700 degrees C, and becomes enough as a heat source of an evaporator 32. The mixed solution of the methanol and water which were supplied through the 1st fuel-supply way 63 mentioned already is made to evaporate here with the elevated-temperature combustion gas of the burner 26 led to the evaporator 32. The original fuel gas which consists of a methanol evaporated with the evaporator 32 and water is led to the 2nd fuel-supply way 64, and is told to the reforming machine 34.

[0079] the original fuel gas with which the reforming machine 34 consists of a supplied methanol and water -- reforming -- hydrogen -- rich fuel gas is generated. The reforming reaction performed with the configuration of this reforming machine 34 and the reforming vessel 34 corresponds to the important section of this invention, and is

explained in full detail behind. In addition, the 2nd temperature sensor 74 is formed in the 2nd fuel-supply way 64 which supplies the original fuel gas which becomes the reforming machine 34 from a methanol and water, and the temperature of the original fuel gas which consists of a methanol supplied to the reforming machine 34 and water is measured. The measurement result about the temperature of this original fuel gas is inputted into a control section 50. In case a control section 50 outputs a driving signal to the 1st pump 70 based on the input result from the 1st temperature sensor 73 mentioned already, it amends the amount of drives of the 1st pump 70 of the above based on the signal from this 2nd temperature sensor 74, and adjusts the amount of methanols supplied to a burner 26. Thus, by controlling the temperature of the combustion gas in a burner 26, the temperature of the above-mentioned Hara fuel gas evaporated with the evaporator 32 is adjusted. The temperature up of the original fuel gas supplied from an evaporator 32 is usually carried out to about 250 degrees C.

[0080] Moreover, at the reforming reaction in the reforming machine 34, oxygen involves so that it may mention later, but in order to supply oxygen required for this reforming reaction, the blower 38 is put side by side in the reforming vessel 34. A blower 38 supplies the air which incorporated air from the exterior, and compressed and incorporated this to the reforming machine 34 through the air supply way 39. In this example, the air supply way 39 is connected to the 2nd fuel-supply way 64, and the air which the blower 38 incorporated is supplied to the reforming machine 34 with the original fuel gas supplied from an evaporator 32. The blower 38 is connected to the control section 50, and the drive condition is controlled by the control section 50.

[0081] CO reduction section 36 is equipment which reduces the carbon monoxide concentration in the fuel gas supplied from the reforming machine 34 through the 3rd fuel-supply way 65. Although the general reforming reaction of a methanol was already shown in (4) types, when a reforming reaction is actually performed, as expressed to these formulas, a reaction does not necessarily advance ideally, and the fuel gas generated with the reforming vessel 34 contains the carbon monoxide of the specified quantity. Then, reduction of the carbon monoxide concentration in the fuel gas supplied to a fuel cell 40 is in drawing by forming CO reduction section 36.

[0082] Although it has the catalyst which consists of the platinum or platinum which the fuel cell 40 of this example is a fuel cell of a solid-state macromolecule mold, and promotes a cell reaction, and other metals (the platinum catalyst was applied to the surface of the electrolyte film 41 in this example) When a carbon monoxide is contained in fuel gas, this carbon monoxide sticks to a platinum catalyst, the function as a catalyst is reduced, the reaction in the anode shown in (1) type will be checked, and the engine performance of a fuel cell will be reduced. Therefore, in order to generate electricity using the fuel cell of a solid-state macromolecule mold like a fuel cell 40, it becomes indispensable to reduce the carbon monoxide concentration in the fuel gas to supply below to the specified quantity, and to prevent cell performance degradation. In addition, in such a polymer electrolyte fuel cell, the threshold limit value as carbon monoxide concentration in the fuel gas supplied is usually about several ppm or less.

[0083] The fuel gas supplied to CO reduction section 36 is hydeogen-rich gas containing the carbon monoxide of the specified quantity, as described above, in CO reduction section 36, priority is given over the hydrogen in fuel gas, and oxidation of a carbon monoxide is performed. CO reduction section 36 is filled up with the support which supported the platinum catalyst which is a selective oxidation catalyst of a carbon monoxide, the ruthenium catalyst, the palladium catalyst, the golden catalyst, or the alloy catalyst that made these the 1st element. The carbon monoxide concentration in the fuel gas processed in this CO reduction section 36 becomes settled with the operating temperature of CO reduction section 36, the carbon monoxide concentration in the fuel gas supplied, the supply flow rate of the fuel gas per unit catalyst volume to CO reduction section 36, etc. The carbon monoxide concentration sensor which is not illustrated is formed in CO reduction section 36, and the operating temperature and the fuel gas flow rate to supply of CO reduction section 36 are adjusted based on this measurement result, and it is controlling so that the carbon monoxide concentration in the fuel gas after processing is set to several ppm or less.

[0084] The fuel gas with which carbon monoxide concentration was lowered as mentioned above in CO reduction section 36 is led to a fuel cell 40 by the 4th fuel-supply way 66, and the cell reaction by the side of cathode is presented with it. As mentioned already, fuel exhaust gas after being used for the cell reaction with the fuel cell 40 is discharged by the fuel exhaust passage 67, is led to a burner 26, and it is consumed as a fuel for combustion of the hydrogen which remains into this fuel exhaust gas. On the other hand, the oxidation gas in connection with the cell reaction by the side of the anode plate of a fuel cell 40 is supplied as the compressed air through the oxidation gas supply way 68 from a compressor 28, as mentioned already. The remaining oxidation exhaust gas used for the cell reaction is discharged outside through the oxidation exhaust gas way 69.

[0085] A control section 50 is constituted as a logical circuit centering on a microcomputer. In detail CPU54 which performs a predetermined operation etc. according to the control program set up beforehand, ROM56 in which a control program, control data, etc. required at CPU54 to perform various data processing were stored beforehand, RAM58 by

which various data required to carry out various data processing by CPU54 similarly is written temporarily, While inputting the detecting signal from the various temperature sensors mentioned already, it has the input/output port 52 grade which outputs a driving signal to the various pumps mentioned already according to the result of an operation in CPU54, a blower 38, etc.

[0086] Next, the configuration of the reforming machine 34 corresponding to the important section of this invention is explained. Drawing 3 is explanatory drawing which expresses the outline of the configuration of the reforming machine 34 typically. The reforming machine 34 of this example receives supply of Hara fuel gas and air from the near edge linked to the 2nd fuel-supply way 64, and a steam-reforming reaction and oxidation reaction (partial oxidation reaction) are presented with these Hara fuel gas and air, passing through the interior of the reforming machine 34. the hydrogen generated by the oxidation reaction shown in the steam-reforming reaction shown in (4) types in the reforming machine 34, and (5) types -- rich fuel gas is discharged by the 3rd fuel-supply way 65 from another edge. This reforming machine 34 equips that interior with the 1st reaction section 80 and the 2nd reaction section 81. These 1st reaction section 80 and the 2nd reaction section 81 are constituted by the surface as a metal honeycomb which supported the Cu-Zn catalyst, and the 1st reaction section 80 formed in the upstream (side near a connection with the 2nd fuel-supply way 64) is formed so that the number of cels mentioned later may become less than the 2nd reaction section 81 formed in the downstream (side near a connection with the 3rd fuel-supply way 65).

[0087] Drawing 4 is a mimetic diagram showing a part of cross section of the metal honeycomb which forms the 1st reaction section 80 and the 2nd reaction section 81. A metal honeycomb carries out the laminating of the stainless plates 82 and 83, and is formed. That is, the plate-like stainless plate 82 and the stainless plate 83 bent in the shape of a wave are arranged by turns, and the metal honeycomb is formed. Since the stainless plate 83 is bent in the shape of a wave at intervals of 1mm, it can form the honeycomb which a length of one side becomes from the cel which has the cross section of the abbreviation square which is 1mm by carrying out the laminating of this stainless plate 83 and the plate-like stainless plate 82 by turns.

[0088] Here, in the 1st reaction section 80 and the 2nd reaction section 81, the thickness of the stainless plates 82 and 83 used in order to form a metal honeycomb differs, and of this, the numbers of cels which each equips with the 1st reaction section 80 and the 2nd reaction section 81 differ, and it is formed. The 1st reaction section 80 consists of a honeycomb formed by the stainless plates 82 and 83 whose thickness is 0.1mm, and the 2nd reaction section 81 consists of a honeycomb formed by the stainless plates 82 and 83 whose thickness is 0.03mm. Therefore, the 1st reaction section 80 is 2 the cross section of 1cm. Having the cel of about 75 hits, similarly the 2nd reaction section 81 is 2 1cm. It will have the cel of about 91 hits. In the reforming machine 34 whole, the gross area (total of the cross section of each cel which constitutes the 1st reaction section 80) of the cross section of the gas passageway in the 1st reaction section 80 becomes smaller than the gross area (total of the cross section of each cel which constitutes the 2nd reaction section 81) of the cross section of the gas passageway in the 2nd reaction section 81 by constituting a honeycomb with the stainless plate with which thickness differs as described above, since the cross section is fixed.

[0089] since the 1st reaction section 80 and the 2nd reaction section 81 are supporting the catalyst on the honeycomb surface which constitutes each, if original fuel gas is supplied from the upstream, while passing through the above-mentioned honeycomb surface, they will present a steam-reforming reaction and oxidation reaction with original fuel gas -- having -- hydrogen -- it becomes rich fuel gas. In this example, the catalyst which the honeycomb surface is made to support was manufactured with the coprecipitation method using copper and a zinc oxide. The Cu-Zn catalyst acquired with the coprecipitation method can grind this, can add binders, such as alumina sol, further, and can be made to support them on a honeycomb by the method of applying on a honeycomb.

[0090] If original fuel gas is supplied to the reforming machine 34 constituted as mentioned above, original fuel gas will pass through the inside of the 1st reaction section 80 with the small gross area of a gas-passageway cross section with few [namely,] cels first, next will pass through many [the number of cels / namely,] inside of the 2nd reaction section 81 with the large gross area of a gas-passageway cross section. Thus, after the original fuel gas of the specified quantity passes through the inside of a honeycomb with the small gross area of a gas-passageway cross section, in order to pass through the inside of a honeycomb with the large gross area of a gas-passageway cross section, the rate of flow of the original fuel gas which passes through the inside of the reforming machine 34 becomes quicker than the time of the direction when passing through the inside of the 1st reaction section 80 passing through the inside of the 2nd reaction section 81.

[0091] Therefore, according to the reforming machine 34 of the 1st example, by making quick the rate of flow of the original fuel gas in the upstream, the rapid temperature rise in the upstream is suppressed and the effect of equalizing the temperature-distribution condition in [whole] the reforming machine 34 in the 250-300-degree C temperature requirement which is a temperature requirement suitable for a reforming reaction is done so. Drawing 5 is explanatory

drawing which expressed the temperature-distribution condition of the interior about the flow direction of gas about the reforming machine known conventionally [with the fixed honeycomb cross section], and the reforming machine 34 of this example. As mentioned already, since the reaction rate is quicker than a steam-reforming reaction, with the conventional reforming vessel, oxidation reaction will advance actively near the entry section of original fuel gas, and, as for oxidation reaction, the temperature near [this] the entry section will rise at about 400 degrees C. On the other hand, with the reforming vessel 34 of this example, since the rate of flow of the original fuel gas in the upstream is quick, the heat produced by the oxidation reaction which advanced by the upstream is promptly carried to the downstream by the flow of quick gas. Moreover, since the rate of flow of the original fuel gas in the upstream is quick, the field where oxidation reaction is not completed in the narrow field of the upstream, and oxidation reaction advances actively spreads in the downstream more. Therefore, temperature does not rise rapidly near the entry section. Furthermore, since the 1st reaction section 80 arranged in the upstream is equipped with the honeycomb formed using the thick stainless plate, it has big heat capacity, and the heat produced in oxidation reaction has become that it is easy to be told to the downstream by the flow of gas, before being told to this honeycomb and carrying out the temperature up of the honeycomb.

[0092] Thus, since temperature does not rise rapidly near [the] the entry section, the reforming machine 34 can prevent un-arranging [which it is called generating of the catalyst de-activation resulting from a temperature rise mentioned already, or a by-product]. By suppressing deterioration of a catalyst, it became possible to raise the endurance of a reforming machine greatly, and, as for the reforming machine 34 of this example, use of 5000 hours or more was attained to having been the endurance whose conventional reforming machine is about time 200 hour.

[0093] Moreover, as described above, while the field where oxidation reaction advances spreads in the downstream, with the reforming vessel 34 of this example, temperature does not fall too much like the reforming machine conventional by the downstream by carrying promptly the heat produced in the oxidation reaction which advanced by the upstream to the downstream. Therefore, also in the downstream of a reforming machine, it is maintained at the condition that the activity of a steam-reforming reaction is high, and while also fully being able to use the catalyst with which the downstream is equipped, the speed of a steam-reforming reaction can be raised. Thus, it becomes possible by raising the activity of the steam-reforming reaction in the downstream to use a reforming machine as a compact more.

[0094] Although the honeycomb with which the reforming machine 34 is equipped considered as the metal honeycomb in the 1st above-mentioned example, it is good also as using a ceramic honeycomb. The configuration using a metal honeycomb is shown below as a modification of the 1st example. The reforming machine in this modification as well as the reforming machine 34 of the 1st example consists of the 1st reaction section 80 and the 2nd reaction section 81. The mimetic diagram of the cross section of the 1st reaction section 80 formed by the ceramic honeycomb and the 2nd reaction section 81 is shown in drawing 6 . Drawing 6 (A) expresses the 2nd reaction section 81 which constitutes an example of the 1st reaction section 80 constituted from a ceramic honeycomb, and drawing 6 (B) from other examples of the 1st reaction section 80, and similarly constitutes drawing 6 (C) from a ceramic honeycomb.

[0095] In drawing 6 (A), the gross area of the passage cross section of gas is made small compared with the honeycomb of drawing 6 (C) by forming small the cross section of each cel which constitutes a honeycomb, respectively, and lessening the total of the cel which constitutes a honeycomb from drawing 6 (B). Therefore, also when using which the 1st reaction section 80 of drawing 6 (A) and drawing 6 (B), the same effect as the 1st example mentioned already can be acquired by constituting the reforming machine 34 combining the 2nd reaction section 81 expressed to drawing 6 (C).

[0096] Moreover, although considered as the configuration from which the rate of flow of the original fuel gas which divides the interior of the reforming machine 34 into two, the 1st reaction section 80 and the 2nd reaction section 81, and passes through the interior in the section the first portion and the second half differs in the above-mentioned example, it is good also as a configuration which divides the interior of a reforming machine or more into three. Also in this case, the same effect as the above-mentioned example can be acquired by considering as the configuration to which the gas flow rate of the upstream becomes quicker than the downstream.

[0097] In the example mentioned already, the gross area of the gas-passageway cross section in the upstream is made small in the honeycomb arranged in the upstream of a reforming machine compared with the downstream by lessening the number of the cels per unit cross section, or forming the cross section of each cel small. The configuration which forms the cross section of the whole reforming machine other than a configuration of having mentioned already as a configuration of the reforming machine with which the gas flow rate of the upstream becomes quicker than the downstream so that it may become smaller by the upstream can be mentioned. The configuration of such reforming machine 34A is shown in drawing 7 . Reforming machine 34A consists of three honeycombs from which a gross area differs, and is formed of as small the honeycomb of a gross area as the upstream. Since such a configuration, then the gas flow rate of the upstream become quicker than the downstream, the same effect as the example mentioned already

can be acquired. The temperature-distribution condition of the interior in reforming machine 34A is shown in drawing 5. If it considers as the configuration which enlarges the gross area of the whole reforming machine gradually like the above-mentioned reforming machine 34A, the number of cels per unit cross section and the cross section of each ** cel may be the same. Moreover, if it is good also as consisting of two or more parts other than three and the upstream is considered as the configuration to which the gross area of a passage cross section becomes small in case two or more parts where gross areas differ constitute a reforming machine, the effect mentioned already can be acquired.

[0098] Next, the configuration which holds the catalyst which promotes a steam-reforming reaction and oxidation reaction by the support formed with a thermally conductive, comparatively high material as other configurations which transmit positively to the downstream the heat produced by the oxidation reaction which advances in the upper section of a reforming machine is explained below as the 2nd example. Drawing 8 is explanatory drawing which expresses the configuration of the reforming machine 90 of the 2nd example typically. The fuel cell equipment 20 of drawing 1 and the fuel cell equipment of the same configuration are equipped with the reforming machine 90 of the 2nd example. As shown in drawing 8, the reforming machine 90 consists of the single reaction section 92 constituted by the honeycomb. Drawing 9 which expresses typically signs that a part of surface (range surrounded with the circle as a field B in drawing 9 (A)) of the honeycomb which showed the cross section showing a part of cross section of the honeycomb which constitutes this reaction section 92 to drawing 9 (A) again at drawing 9 (A) was expanded further is shown in drawing 9 (B).

[0099] The reforming machine 90 of this example is constituted by the metal honeycomb like the reforming machine 34 of the 1st example. In addition, in this example, thickness formed the honeycomb using the stainless plate 94 which is 0.05mm. The catalyst which promotes a steam-reforming reaction and oxidation reaction is contained in the surface of this stainless plate 94, and the catalyst bed 96 whose thickness is about 0.05mm is formed in it. At the catalyst bed 96, the copper content child and zinc oxide molecule which constitute a Cu-Zn catalyst are supported with the condition of having distributed in the thermally conductive high binder.

[0100] Here, the preparation method of a catalyst bed 96 is explained. First, as a catalyst raw material, CuO-ZnO powder is produced with a well-known coprecipitation method, and thermally conductive high material is added [alumina sol 5% / further] at this to an aluminum oxide as a binder. It is carbonization silicon (SiC) and boron carbide (B4C) which are the alumimium nitride (AlN) which is a nitride, titanium nitride (TiN), or carbide as thermally conductive high material used here, Or graphite etc. can be mentioned and 5 - 30% is desirable as an addition. For example, in the above-mentioned thermally conductive high material, AlN shows 0.07 cal/cm/s/degree C thermal conductivity, SiC shows 0.1cal/cm/s/degree C, graphite shows 0.30.1 cal/cm/s/degree C thermal conductivity, and all show high thermal conductivity compared with the aluminum oxide (0.02cal/cm/s/degree C) used conventionally.

[0101] These are diluted with water, grinding mixing is carried out with a ball mill, it applies on a stainless plate 94, and heat-treatment and reduction processing are performed further. By such processing, the above-mentioned catalyst raw material serves as a Cu-Zn catalyst which consists of a copper content child and a zinc-oxide molecule, and these Cu-Zn catalysts are in the condition distributed and supported in the binder containing thermally conductive high material, and form a catalyst bed 96.

[0102] If the reforming machine 90 constituted as mentioned above is applied to fuel cell equipment 20 and original fuel gas is supplied to the reforming machine 90, as mentioned already, in the upstream to which oxygen is supplied, oxidation reaction will be performed actively and many heat will arise. Thus, the inside of the binder containing the thermally conductive high material which it was used at the steam-reforming reaction which advances by the upstream, and also was mentioned already is promptly told to the heat produced by oxidation reaction. Thus, the specified quantity of the heat to which the inside of a binder is told is further told to the honeycomb base material formed with thermally conductive high stainless steel. The heat told to the honeycomb base material which consists of stainless steel is told to the downstream through this honeycomb base material. Moreover, the inside of a binder is told to the remaining heat which is not told to a honeycomb base material by the downstream as it is. Thus, the heat told to the downstream of the reforming machine 90 is used at the steam-reforming reaction which advances by the downstream.

[0103] Therefore, according to the reforming machine 90 of this example, since the catalyst is supported in the thermally conductive high binder, the heat produced in the upstream for oxidation reaction is promptly told to the downstream, and the rapid temperature rise in the upstream can be suppressed. Drawing 10 is explanatory drawing which stuck with the reforming machine known conventionally using the binder which does not contain the high material of the above-mentioned pyroconductivity, and the reforming machine 90 of this example, and expressed the temperature-distribution condition of the interior about the flow direction of gas. The reforming machine 90 of this example can equalize the internal temperature of a reforming machine in a 250-300-degree C temperature requirement, without carrying out the temperature up of the upstream rapidly, since the heat produced in the oxidation reaction which

advances by the upstream is promptly told to the downstream unlike the conventional reforming machine. Thus, since temperature does not rise rapidly near [the] the entry section, the reforming machine 90 can prevent un-arranging [which it is called generating of the catalyst de-activation resulting from a temperature rise mentioned already, or a by-product]. By suppressing deterioration of a catalyst, it became possible to raise the endurance of a reforming machine greatly, and, as for the reforming machine 90 of this example, use of 5000 hours or more was attained to having been the endurance whose conventional reforming machine is about time 200 hour.

[0104] Moreover, since the heat produced by the oxidation reaction which advanced by the upstream is promptly told to the downstream as described above, with the reforming vessel 90 of this example, temperature does not fall too much like the reforming machine conventional in the downstream region. Therefore, also in the downstream of a reforming machine, it is maintained at the condition that the activity of a steam-reforming reaction is high, and while also fully being able to use the catalyst with which the downstream is equipped, the speed of a steam-reforming reaction can be raised. Therefore, it becomes possible to use a reforming machine as a compact more.

[0105] In the 2nd example of the above, since the catalyst bed 96 using the binder containing thermally conductive high material formed on the honeycomb which uses the stainless plate excellent in thermal conductivity as a base material, heat conduction from the upstream to a lower stream of a river was able to acquire what is depended on catalyst bed 96 self, and the effect which both were performed through the stainless plate 94, and could perform heat transfer and were especially excellent in high effectiveness. Here, a catalyst bed 96 can be formed on a ceramic honeycomb, or a catalyst can be fabricated to a pellet type with a thermally conductive high binder, and the predetermined effect by the thermal conductivity from the upstream to the downstream improving also as a configuration with which it is filled up in a reforming machine can be acquired.

[0106] Next, by lessening the amount of catalysts which the upstream in a reforming machine supports as the 3rd example compared with the downstream shows below the configuration which suppressed the activity of oxidation reaction in the upstream. Drawing 11 is explanatory drawing which expresses the configuration of the reforming machine 100 of the 3rd example typically. The fuel cell equipment 20 of drawing 1 and the fuel cell equipment of the same configuration are equipped with this reforming machine 100. As shown in drawing 11, the reforming machine 100 is equipped with the 1st reaction section 101 and the 2nd reaction section 102. These 1st reaction section 101 and the 2nd reaction section 102 are constituted by the honeycomb of the same configuration, and although the same Cu-Zn catalyst as the example mentioned already on this honeycomb surface is supported, the amount of the 2nd reaction section 102 of the catalyst supported on the honeycomb is more than the 1st reaction section 101. That is, the 2nd reaction section 102 is supporting the Cu-Zn catalyst with the rate of 180 g/l to the 1st reaction section 101 supporting the Cu-Zn catalyst with the rate of 50 g/l (the amount of catalysts per unit volume of a honeycomb).

[0107] Since there are few amounts of catalysts which the 1st reaction section 101 of the upstream supports according to the reforming machine 100 constituted as mentioned above, advance of the oxidation reaction by the installation side of original fuel gas and air is suppressed. Therefore, the field where oxidation reaction does not advance rapidly by the upstream of a reforming machine, and oxidation reaction is performed spreads in the downstream more. Therefore, the rapid temperature rise in the upstream can be suppressed.

[0108] Drawing 12 is explanatory drawing which expressed the temperature-distribution condition of the interior about the flow direction of gas about the reforming machine with which it is known conventionally which was equipped with the honeycomb with which the catalyst of the downstream and tales doses is supported also for the upstream, and the reforming machine 100 of this example. The reforming machine 100 of this example can equalize the internal temperature of a reforming machine in a 250-300-degree C temperature requirement, without carrying out the temperature up of the upstream rapidly, since advance of oxidation reaction is suppressed by the upstream unlike the conventional reforming machine. Thus, since temperature does not rise rapidly near [the] the entry section, the reforming machine 100 can prevent un-arranging [which it is called generating of the catalyst de-activation resulting from a temperature rise mentioned already, or a by-product]. By suppressing deterioration of a catalyst, it became possible to raise the endurance of a reforming machine greatly, and, as for the reforming machine 100 of this example, use of 5000 hours or more was attained to having been the endurance whose conventional reforming machine is about time 200 hour.

[0109] Moreover, since the field where the oxidation reaction accompanied by pyrexia advances spreads in the downstream more as described above, with the reforming vessel 100 of this example, temperature does not fall too much like the reforming machine conventional in the downstream region. Therefore, also in the downstream of a reforming machine, it is maintained at the condition that the activity of a steam-reforming reaction is high, and while also fully being able to use the catalyst with which the downstream is equipped, the speed of a steam-reforming reaction can be raised. Therefore, it becomes possible to use a reforming machine as a compact more.

[0110] In addition, although carried out to changing the amount of catalysts to support to two steps in the reforming machine 100 in the 3rd example of the above, it is good also as making it change more than a three-stage, and the above-mentioned predetermined effect can be acquired by reducing the amount of catalyst support of the upstream. By considering as the configuration whose upstream reduces the amount of support of a catalyst here, and adjusting the number of the phases of changing the amount of support of a catalyst, it becomes possible to make the temperature inside a reforming machine equalize more, and the effect mentioned already can be heightened.

[0111] Moreover, although [the 3rd example of the above / a steam-reforming reaction and oxidation reaction] promoted according to the same Cu-Zn catalyst, it is good also as promoting a steam-reforming reaction and oxidation reaction according to a different catalyst. In such a case, what is necessary is to lessen only the amount of support of the catalyst which promotes oxidation reaction by the upstream instead of changing the total amount of support of a catalyst by the upstream and the downstream of a reforming machine.

[0112] Next, while suppressing the activity of the oxidation reaction by the upstream by lowering the oxygen density in the gas supplied to a reforming machine as the 4th example, the configuration which tells the heat which sped up the rate of flow of the gas to supply and was produced in the oxidation reaction in the upstream to the downstream is shown. Drawing 13 is explanatory drawing which expresses the configuration of the reforming machine 110 of the 4th example typically. The fuel cell equipment 20 of drawing 1 and the fuel cell equipment of the almost same configuration are equipped with this reforming machine 110, and it gives the same member number to a common member, and performs the following explanation.

[0113] Here, although the reforming machine was supplied in the example mentioned already after the air supply way 39 which supplies air to a reforming machine from a blower 38 once joined the 2nd fuel-supply way 64 and original fuel gas had air mixed, direct continuation of the above-mentioned air supply way 39 is carried out to the reforming machine 110 with fuel cell equipment equipped with the reforming machine 110 of the 4th example. Moreover, with fuel cell equipment equipped with the reforming machine 110 of this example, the oxidation exhaust gas discharged by the oxidation exhaust gas way 69 from a fuel cell 40 can also be supplied to the reforming machine 110 with the air incorporated from a blower 38. Although about 20% of oxygen contains to the usual air, since the oxygen of the specified quantity is consumed by electrochemical reaction [in / in the oxidation exhaust gas discharged from a fuel cell / a fuel cell], there are few amounts of oxygen to contain than air. Although the oxygen density in oxidation exhaust gas changes with the excess air factor (the amount of oxygen in the actually supplied air, and the amount of oxygen needed theoretically comparatively) in the oxidation gas supplied to a fuel cell etc., with the fuel cell equipment of this example, the oxygen density in oxidation exhaust gas becomes about 10%. Therefore, it becomes possible by mixing air and oxidation exhaust gas and making supply possible to the reforming machine 110, to adjust the oxygen density in the air supplied to the reforming machine 110 by about 10% - about 20% of within the limits.

[0114] Based on drawing 13, the configuration of the reforming machine 110 is explained in detail. The reforming machine 110 is equipped with the single reaction section 111 constituted by the honeycomb with which the Cu-Zn catalyst was supported by the surface. Moreover, the above-mentioned air supply way 39 and the oxidation exhaust gas way 69 join, and turn into the 2nd air supply way 115, and this 2nd air supply way 115 supplies the mixture of gas (it is hereafter called mixed air) of air and oxidation exhaust gas in the reforming machine 110 to the upstream to which original fuel gas is supplied from the 2nd fuel-supply way 64. The mass flow controller 112 is formed near the unification section to the 2nd air supply way 115, and accommodation of the air content supplied to the 2nd air supply way 115 side is attained on the air supply way 39. Moreover, similarly the mass flow controller 113 is formed near the unification section to the 2nd air supply way 115, and accommodation of the oxidation amount of exhaust gas supplied to the 2nd air supply way 115 side is attained on the oxidation exhaust gas way 69. These mass flow controller 112, 113 is connected to the control section 50 mentioned already, and the amount of mixing at the time of the air supplied from the air supply way 39 and the oxidation exhaust gas supplied from the oxidation exhaust gas way 69 being mixed is controlled by the control section 50. Furthermore, the oxygen density sensor 114 is formed in the 2nd air supply way 115. This oxygen density sensor 114 is also connected to the control section 50, and the information about the oxygen density in mixed air can input into a control section 50. Moreover, in the reaction section 111 interior, the temperature sensor 117 is formed in the position from the edge of the upstream. This temperature sensor 117 is also connected to the control section 50, and the information about the temperature in the reaction section 111 can input into a control section 50.

[0115] It makes the rate of flow of the whole gas which passes through the inside of the reaction section 111 increase, and suppresses that temperature rises rapidly in the upper section of the reforming machine 110 while it reduces the oxygen density in this mixed air, in case the reforming machine 110 of this example supplies the mixed air containing the oxygen of the specified quantity to the reforming machine 110. That is, by reducing the oxygen density in the mixed

air supplied to the reforming machine 110, the oxygen density in the gas which passes through the inside of the reaction section 111 also falls, the activity of the oxidation reaction by the upstream is suppressed by it, and a rapid temperature rise can be prevented by it. Moreover, by reducing the oxygen density in the mixed air containing the oxygen of the specified quantity, the mixed air content supplied to the reaction section 111 increases, and the rate of flow of the gas which passes through the inside of the reaction section 111 speeds up. Before oxygen is used up by it by the oxidation reaction which advances by the upstream, oxygen is carried more to the downstream and the field where oxidation reaction advances can be extended more to the downstream. Furthermore, it can prevent telling the heat produced in the oxidation reaction which advances by the upstream promptly to the downstream, and the upstream of the reaction section carrying out a temperature up too much by speeding up the rate of flow of the gas which passes through the inside of the reaction section 111.

[0116] Drawing 14 is a flow chart showing the amount control manipulation routine of air mixing performed with fuel cell equipment equipped with the reforming machine 110 of this example. In fuel cell equipment equipped with the reforming machine 110, this routine will be performed for every predetermined time amount, if the reforming machine 110 interior is judged to fully have carried out the temperature up and to have reached the steady state after starting of this fuel cell equipment is directed by operating the predetermined start switch which is not illustrated.

[0117] If this routine is performed, CPU54 will read first the amount of methanols in the original fuel gas supplied to the reforming machine 110 based on the amount of drives of the 2nd pump 71 formed in the methanol passage 60 (step S200). Next, based on this amount of methanols, the amount of oxygen which should be supplied to the reforming machine 110 is calculated, and the mass flow controller 112,113 is driven so that supply of the oxygen of an initial complement may be attained (step S210). That is, if the amount of methanols supplied to a reforming machine is determined, since the amount of oxygen required in order to balance the quantity of heat which a steam-reforming reaction takes, and the quantity of heat produced in oxidation reaction can be determined, the mass flow controller 112,113 is driven so that the air containing this determined amount of oxygen may be supplied to the reforming machine 110. Here, when the amount of oxygen which should be supplied is determined, the amount of drives which drives each mass flow controller in order to supply the amount of oxygen which should be supplied is beforehand determined to each amount of supply oxygen as an amount of criteria drives, and is memorized in the control section 50.

[0118] Internal temperature T1 of the upstream in the reaction section 111 from a temperature sensor 117 if it begins to supply the mixed air which drives the mass flow controller 112,113 and contains the oxygen of an initial complement to the reforming machine 110 next It reads (step S220). Next, this internal temperature T1 It compares with the predetermined reference temperature Ta (step S230). Here, it is the predetermined reference temperature Ta. Internal temperature T1 of the upstream It is the value which set up beforehand as a maximum and the control section 50 was made to memorize, and could be 300 degrees C in this example.

[0119] It sets to step S230 and is the internal temperature T1 of the upstream. When smaller than the above-mentioned predetermined reference temperature Ta, it is the internal temperature T1 of the upstream of the reaction section 111. It is judged that it is a temperature low enough and this routine is ended as it is. When the internal temperature T1 of the upstream is more than the above-mentioned predetermined reference temperature Ta, while reducing the amount of drives of the mass flow controller 112, the amount of drives of the mass flow controller 113 is increased. That is, the rate of oxidation exhaust gas is made to increase in the mixed air supplied to the reforming machine 110, without changing the amount of oxygen supplied to per unit time amount (step S240). In this example, the variation of the rate of the oxidation exhaust gas in this step S240, i.e., the variation of the oxygen density in the mixed air supplied to the reforming machine 110, defines the variation of a smallest unit beforehand, and it carried out to reducing an oxygen density for every smallest unit of this. Or internal temperature T1 It is good also as adjusting according to the amount exceeding reference temperature Ta. Since the oxygen density in the whole gas supplied to the reforming machine 110 by making the rate of oxidation exhaust gas increase falls, the oxidation reaction which advances by the upstream is suppressed. Moreover, the mixed air content supplied to the reforming machine 110 increases by making the rate of oxidation exhaust gas increase, without changing the amount of oxygen supplied to per unit time amount, the rate of flow of the gas which passes through the inside of the reforming machine 110 speeds up, and the heat produced in the oxidation reaction which advances by the upstream comes to be more promptly carried to the downstream. Therefore, it is the internal temperature T1 of the upstream of the reaction section 111 by performing step S240. It can lower.

[0120] When the rate of oxidation exhaust gas is changed in step S240 next, it returns to step S220 again, and is the internal temperature T1. Reading and this internal temperature T1 Actuation of the comparison with the predetermined reference temperature Ta is repeated. When the internal temperature T1 becomes lower than the predetermined reference temperature Ta in step S230, the rate of the oxidation exhaust gas in the mixed air supplied to the reforming machine 110 becomes suitable, and it is the internal temperature T1 of the upstream of the reaction section 111. It is

judged that it became low enough and this routine is ended.

[0121] In addition, fuel cell equipment equipped with the reforming machine 110 of this example equips the 2nd air supply way 115 with the oxygen density sensor 114, as mentioned already, and it amends the oxygen density in the mixed air supplied to the reforming machine 110 based on the detection result. That is, in step S210 or step S240 in the above-mentioned amount control manipulation routine of air mixing, when a mass flow controller is driven, the oxygen density sensor 114 detected the oxygen density in the mixed air supplied to the reforming machine 110, and the amount of drives of a mass flow controller is amended based on the result.

[0122] Since the oxygen density in the mixed air supplied to the reforming machine 110 is controllable according to fuel cell equipment equipped with the reforming machine 110 of the 4th example constituted as mentioned above, it can stop that oxidation reaction advances to the installation side of original fuel gas and mixed air by making low the oxygen density in the above-mentioned mixed air. Therefore, the rapid temperature rise in the upstream can be suppressed. Furthermore, supplying the oxygen of the specified quantity to the reforming machine 110 per unit time amount, by lowering the oxygen density in mixed air, the flow rate of mixed air increases and the rate of flow of the gas which passes through the reaction section 111 interior speeds up. Therefore, it can suppress that the heat produced in the oxidation reaction which advances by the upstream is promptly told to the downstream, and temperature rises too much by the upstream.

[0123] Moreover, since the field where oxidation reaction advances by suppressing oxidation reaction in the upstream spreads in the downstream more as described above, with the reforming vessel 110 of this example, temperature does not fall too much like the reforming machine conventional in the downstream region. Furthermore, since the heat produced in the upstream when the rate of flow of the gas which passes through the reaction section 111 interior sped up becomes that it is easy to be told to the downstream, a temperature fall in a downstream region is suppressed further. Therefore, with the reforming vessel 110, it is maintained at the condition that the activity of a steam-reforming reaction is high, also in the downstream, and while also fully being able to use the catalyst with which the downstream is equipped, the speed of a steam-reforming reaction can be raised. Therefore, it becomes possible to use a reforming machine as a compact more.

[0124] In the 4th example of the above, it judges whether the amount of methanols in the original fuel gas supplied to the reforming machine 110 is read based on the amount of drives of the 2nd pump 71 formed in the methanol passage 60, and oxidation reaction is advancing superfluously in the upstream based on the detection result of a temperature sensor 117. It is good also as performing such decision about the amount of methanols supplied to the reforming machine 110, and the advance condition of the oxidation reaction and steam-reforming reaction in the reforming machine 110, using further measurands measurands other than the above, or other than the above. For example, in order to judge the advance condition of the steam-reforming reaction and oxidation reaction in the reforming machine 110 The device which can analyze the component in the gas which passes through the 3rd fuel-supply way 65 is arranged in the 3rd fuel-supply way 65. It is good also as measuring amounts, such as a methanol in the fuel gas discharged from the reforming machine 110, hydrogen, a carbon dioxide, and oxygen, using this measurement result further, and judging the advance condition of the steam-reforming reaction in the reforming machine 110, and oxidation reaction.

[0125] Although mixed air was considered as the configuration supplied only from the upstream of the reforming machine 110 in the 4th example of the above, the configuration which supplies mixed air from two or more places is also desirable. Such a configuration is shown below as a modification of the 4th example. Drawing 15 is explanatory drawing which expresses typically the configuration of reforming machine 110A which is the modification of the 4th example. Reforming machine 110A is equipped with the two reaction sections 111A and 111B, and mixed oxygen is supplied to each reaction section. Here, the original fuel gas supplied to reforming machine 110A is passed in order of the reaction sections 111A and 111B. Moreover, the air supply way 39 and the oxidation exhaust gas way 69 which supply air and oxidation exhaust gas to reforming machine 110A branch to the air fork roads 39A and 39B and the oxidation exhaust gas fork roads 69A and 69B, respectively. Air fork road 39A and oxidation exhaust gas fork road 69A join, turn into 2nd air supply way 115A, and supply mixed air to reaction section 111A arranged in the upstream. Air fork road 39B and oxidation exhaust gas fork road 69B join, turn into 2nd air supply way 115B, and supply mixed air to reaction section 111B arranged in the downstream. The amount of oxygen and oxygen density in the mixed air supplied to each reaction section are controlled like the 4th example based on the amount of methanols supplied to reforming machine 110A, the temperature of the upstream of each reaction section, etc. by adjusting the amount of drives of the mass flow controllers 112A, 112B, 113A, and 113B.

[0126] According to reforming machine 110A constituted as mentioned above, since mixed air is divided and supplied, the amount of oxygen in the mixed gas supplied at once can be reduced, and the effect which prevents temperature rising too much locally can be heightened further. Furthermore, by dividing the interior of a reforming machine into two

or more reaction sections, and supplying mixed air for every reaction section, it becomes possible to control the temperature distribution inside a reforming machine with a more sufficient precision, and the whole interior of a reforming machine can be kept easier to a desirable temperature requirement.

[0127] Drawing 16 is explanatory drawing which stuck with reforming machine 110A mentioned above, and expressed the temperature-distribution condition of the interior about the flow direction of gas as the reforming machine known conventionally supplies only the usual air to a reforming machine as a source of oxygen which oxidation reaction takes. Reforming machine 110A can equalize the internal temperature of a reforming machine in a 250-300-degree C temperature requirement, without carrying out the temperature up of the upstream rapidly, since advance of the oxidation reaction in the upstream is suppressed unlike the conventional reforming machine. As explained above, since temperature does not rise rapidly near [the] the entry section, the reforming machines 110 and 110A of this example can prevent un-arranging [which it is called generating of the catalyst de-activation resulting from a temperature rise mentioned already, or a by-product]. Therefore, it becomes possible like the example mentioned already to raise the endurance of a reforming machine greatly.

[0128] Moreover, although [the reforming machines 110 and 110A of the example mentioned already] it has the reaction section constituted by the honeycomb, they are good also as a configuration which fills up the interior of a reforming machine with the pellet which supported the catalyst. Also in this case, the same effect by making controllable the oxygen density in the mixed air supplied to a reforming machine as a source of oxygen which oxidation reaction takes can be acquired.

[0129] It is also possible to prevent changing the field which heat produces and temperature rising too much locally by enabling modification of the field where oxidation reaction advances actively, and the field where advance of oxidation reaction is inactive in the interior of the catalyst section, although it was made a rapid temperature rise not happen by the upstream in the 3rd and 4th examples of the above by suppressing the activity of the oxidation reaction which advances by the upstream of a reforming machine. the entry section in which original fuel gas and oxygen are introduced into below as such a configuration, and hydrogen -- the outlet section by which rich fuel gas is discharged explains a switchable reforming machine as the 5th example.

[0130] Drawing 17 is explanatory drawing which expresses the configuration of the reforming machine 120 of the 5th example typically. The fuel cell equipment 20 of drawing 1 and the fuel cell equipment of the same configuration are equipped with this reforming machine 120. As shown in drawing 17, the reforming machine 120 is equipped with the single reaction section 121 constituted by the honeycomb which supports a Cu-Zn catalyst on the surface. This reaction section 121 is equipped with the temperature sensor 122 and temperature sensor 123 which measure the internal temperature of those both ends. These temperature sensors are connected to the control section 50 mentioned already, and the information about the internal temperature in the both ends of the reaction section 121 is inputted into a control section 50.

[0131] Moreover, in this example, the 2nd fuel-supply way 64 has branched to the 1st supply fork road 124 and the 2nd supply fork road 125, and connects each fork road to each edge of the reforming machine 120. Here, it connects with the above-mentioned 1st supply fork road 124, and also the end of the reforming machine 120 is connected with the 1st discharge fork road 126. Moreover, it connects with the above-mentioned 2nd supply fork road 125, and also the other end of the reforming machine 120 is connected with the 2nd discharge fork road 127. These 1st discharge fork roads 126 and 2nd discharge fork roads 127 join, turn into the 3rd fuel-supply way 65, and are connected to CO reduction section 36. Furthermore, solenoid valves 128,129,128A and 129A are formed in the above-mentioned 1st supply fork road 124, the 2nd supply fork road 125, the 1st discharge fork road 126, and the 2nd discharge fork road 127, respectively. These solenoid valves 128,129,128A and 129A are connected to the control section 50, and the switching condition is controlled by the control section 50.

[0132] With such a reforming vessel 120, the switching condition of the above-mentioned solenoid valve usually turns into the 1st condition that solenoid valves 128 and 128A will be in an open condition, and solenoid valves 129 and 129A will be in a closed state, or the 2nd condition that solenoid valves 129 and 129A will be in an open condition, and solenoid valves 128 and 128A will be in a closed state. When the switching condition of a solenoid valve will be in the 1st condition of the above, the original fuel gas supplied from the 2nd fuel-supply way 64 is passed toward right-hand side from the left-hand side in drawing 13 in the reaction section 121. Moreover, when the switching condition of a solenoid valve will be in the 2nd condition of the above, original fuel gas is passed toward left-hand side from the right-hand side in drawing 13 in the reaction section 121.

[0133] Drawing 18 is a flow chart showing the gas entry change manipulation routine performed with fuel cell equipment 20, in case the change of the entry section of gas which was described above in the reforming machine 120 is performed. In fuel cell equipment 20, this routine will be performed for every predetermined time amount, if starting of

fuel cell equipment 20 is directed by operating the predetermined start switch which is not illustrated.

[0134] If this routine is performed, CPU54 will judge first whether the switching condition of a solenoid valve is in the 1st condition from the switching condition of each solenoid valve mentioned already (step S300). Internal temperature T1 in the edge of the upstream to which gas is supplied when it is judged that it is in the 1st condition It reads from a temperature sensor 122 (step S310). Next, this internal temperature T1 Predetermined reference temperature T0 set up beforehand It compares (step S320). Here, it is the predetermined reference temperature T0. The internal temperature of the reaction section 121 is the value made to memorize in a control section 50 beforehand as a temperature used as the criteria which show that a temperature up is changed into the condition of not wanting, and was set as 300 degrees C by this example. It sets to step S320 and is the internal temperature T1. Reference temperature T0 When having not reached, they are return and the internal temperature T1 to step S310. Reference temperature T0 Reading of the above-mentioned internal temperature and comparative actuation are repeated until it reaches.

[0135] It sets to step S320 and is the internal temperature T1. Reference temperature T0 While making all solenoid valves into a closed state if it is judged that it is above next, measurement of elapsed time t is started with the predetermined timer with which the control section 50 was equipped and which it does not illustrate (step S330). By making all valves into a closed state in step S330, it is stopped by receipts and payments of the gas in the reforming machine 120, and the steam-reforming reaction and oxidation reaction using the original fuel gas which remains are continued as it is within the reaction section 121. Next, the predetermined conventional time t0 which set up elapsed time t beforehand It compares (step S340). Here, it is the predetermined conventional time t0. As described above, when all the valves were made into a closed state, it is the value made to memorize in a control section 50 beforehand as time amount taken to complete the steam-reforming reaction and oxidation reaction using the original fuel gas which remains to the reforming machine 120 interior, and was set as 1 sec in this example. It sets to step S340 and elapsed time t is the conventional time t0. When having not reached, it is the conventional time t0. Actuation of step S340 is repeated until it passes. It sets to step S340 and elapsed time t is the conventional time t0. When it reaches, a driving signal is outputted to a predetermined solenoid valve, the switching condition of a solenoid valve is changed into the 2nd condition (step S350), and this routine is ended.

[0136] Moreover, it is the internal temperature T2 in the edge of the upstream to which it is judged that the reforming machine 120 is in the 2nd condition when it is judged in step S300 that it is not in the 1st condition, and gas is supplied. It reads from a temperature sensor 123 (step S360). After that, the same processing even as step S320 mentioned already to step S370 - step S390 - step S340 is performed. That is, it is the internal temperature T2 in advance of oxidation reaction. If the predetermined reference value T0 (this example 300 degrees C) is reached, all valves will be made into a closed state predetermined time (this example 1 sec), the switching condition of a solenoid valve will be changed into the 1st condition after that (step S400), and this routine will be ended.

[0137] in addition, the above-mentioned gas entry change manipulation routine, although it performs for every predetermined time, when starting of fuel cell equipment 20 was directed by operating the predetermined start switch which is not a drawing example, as mentioned already What is necessary is just to make it the switching condition of each solenoid valve be in the 1st above-mentioned condition or the 2nd above-mentioned condition as first condition that starting of fuel cell equipment 20 was directed. For example, in the same condition as the time of suspending fuel cell equipment 20 to last time, it is good for next time also as putting fuel cell equipment 20 into operation, and at the time of starting of fuel cell equipment 20, you may set up so that the switching condition of each solenoid valve may be in the 1st condition of the above, or the 2nd condition.

[0138] Since according to fuel cell equipment equipped with the reforming machine 120 of the 5th example constituted as mentioned above the supply part in the mixed air supplied to the reforming machine 120 can be changed by the upstream and the downstream and the flow direction of the gas in the reaction section 121 can be reversed, only one edge of a reforming machine does not carry out a temperature up too much with the heat produced in oxidation reaction. Therefore, the rapid temperature rise in the upstream can be suppressed. Here, in order to perform the change of the flow direction of gas based on the temperature of the edge of the reaction section 121, it becomes possible about the temperature of the edge of the reaction section 121 rising too much to protect more certainly.

[0139] Moreover, since the both ends of the reaction section 121 can serve as the upstream by changing the flow direction of gas as described above, temperature does not fall too much by the specific downstream like the conventional reforming machine. Therefore, with the reforming vessel 120, it is maintained at the condition that the activity of a steam-reforming reaction is high, on the both sides, and while fully being able to use the catalyst with which the reaction section 121 whole is equipped, the speed of a steam-reforming reaction can be raised. Therefore, it becomes possible to use a reforming machine as a compact more.

[0140] It is explanatory drawing which drawing 19 stuck with the reforming machine known conventionally [with the

fixed flow direction of internal gas], and the reforming machine 120 mentioned above, and expressed the temperature-distribution condition inside [from an end side] an other end side. Since it is stopped unlike the conventional reforming machine that oxidation reaction advances too much to a specific edge side and a both-ends side can turn into the upstream, the reforming machine 120 can equalize the internal temperature of a reforming machine in a 250-300-degree C temperature requirement. As explained above, since temperature does not rise rapidly near [the] the entry section, the reforming machine 120 of this example can prevent un-arranging [which it is called generating of the catalyst deactivation resulting from a temperature rise mentioned already, or a by-product]. Therefore, it becomes possible like the example mentioned already to raise the endurance of a reforming machine greatly.

[0141] In addition, although [the reforming machine 120 of this example] it has the reaction section constituted by the honeycomb, it is good also as a configuration which fills up the interior of a reforming machine with the pellet which supported the catalyst. Also in this case, the same effect by changing the flow direction of the gas which passes reforming circles can be acquired.

[0142] Moreover, based on the temperature of the edge of the reaction section 121 although [the reforming machine 120 of this example] the flow direction of gas is changed, its timing of a change is good also as being based on other factors. Although there is an advantage that a high effect is acquired when maintaining internal temperature within the limits of predetermined also when changing the amount of the original fuel gas supplied to the reforming machine 120 when based on the edge temperature of the reaction section 121 and changing the amount of the steam-reforming reaction and oxidation reaction which advance in the reforming machine 120 interior For example, when fluctuation of the amount of original fuel gas supplied to a reforming machine is small, it is good also as changing the flow direction of gas for every predetermined time amount.

[0143] Next, by agitating the catalyst particle enclosed with the interior of a reforming machine as the 6th example shows the configuration which prevents only the specific upstream in a reforming machine carrying out a temperature up too much. Drawing 20 is explanatory drawing which expresses typically the configuration of the member connected with the reforming machine 130 of the 6th example, and this reforming machine 130. Since the fuel cell equipment 20 of drawing 1 and the fuel cell equipment of the same configuration are equipped with the reforming machine 130 of this example, in the following explanation, it attaches the member number same about a common member, and omits detailed explanation.

[0144] The reforming machine 130 is enclosed with the interior in the particle which consists of a Cu-Zn catalyst mentioned already. This catalyst corns the Cu-Zn catalyst produced with the well-known coprecipitation method so that it may become the particle size of about 500 micrometers. Or it is good also as producing the particle of the particle size described above by supplying and spraying a Cu-Zn catalyst on spray dryer equipment after distributing a predetermined solvent. Moreover, in case the particle size of a catalyst particle injects gas in the reforming machine which encloses this catalyst particle so that it may mention above, it is [that what is necessary is just the magnitude in which it is fully agitated and deals by this gas] desirable [particle size] to consider as the particle size of 100 micrometers - several mm. Moreover, although the configuration of a catalyst particle may be what kind of thing, considering the effectiveness of churning mentioned later, the spherically nearer one is desirable.

[0145] Like the example mentioned already, although air is supplied from a blower 38 while the original fuel gas which consists of a methanol and a steam is supplied from an evaporator 32, by this example, such original fuel gas and air are supplied in the reforming machine 130 through a pressure regulating valve 132 and an injection nozzle 134 by the reforming machine 130. With an evaporator 32, original fuel gas is discharged in the condition that a methanol and water have a predetermined temperature and a predetermined pressure from an evaporator 32 since a temperature up is carried out, evaporation and. This original fuel gas is injected in the reforming machine 130 through a pressure regulating valve 132 and an injection nozzle 134, after being mixed with the air supplied from the air supply way 39. By injecting the original fuel gas containing air, since the catalyst particle is enclosed in the reforming machine 130 as described above, within the reforming machine 130, it flows and a catalyst particle is agitated, as the drawing 20 Nakaya mark shows. Although [here / the reforming machine 130 of this example] injection of the original fuel containing air is performed from seven places, if churning is fully possible in a catalyst particle within a reforming machine, the number of injection parts is good also as a different configuration. Moreover, the capacity of the reforming machine 130 interior should just be the magnitude by which the catalyst particle of the specified quantity may fully be agitated by the gas (original fuel gas containing oxygen) supplied by the predetermined flow rate and the predetermined pressure.

[0146] In the reforming machine 130, the filter 136 formed with foaming nickel is formed in the edge which an injection nozzle connects, and the edge of the opposite side. Although it bars this filter 136 that the catalyst particle enclosed in the reforming machine 130 leaks outside since it is fully formed in the shape of [of an eye] a fine mesh, it does not bar

it that the fuel gas generated within the reforming machine 130 is supplied to CO reduction section 36 side. The fuel gas which passed the filter 136 is supplied to a fuel cell 40, after CO reduction section 36 is supplied and carbon monoxide concentration is reduced.

[0147] Since the catalyst particle which was enclosed in the reforming machine 130 according to fuel cell equipment equipped with the reforming machine 130 constituted as mentioned above is always agitated by the original fuel gas containing air, only the specific field of a catalyst does not carry out the temperature up of it too much with the heat which the catalyst particle which exists in the location to which the original fuel gas containing high-concentration oxygen is supplied always interchanges, and produces in oxidation reaction. Here, since the gas injected in a reforming machine in order to agitate a catalyst particle is gas (original fuel gas containing air) for presenting the steam-reforming reaction and oxidation reaction which advance within a reforming machine, it can perform to coincidence actuation which supplies a original fuel to the reforming machine 130, and actuation which agitates a catalyst particle. Moreover, the electrochemical reaction in the reaction or fuel cell in a reforming machine is not influenced by injecting gas in a reforming machine.

[0148] Moreover, since the heat produced in oxidation reaction is also distributed by churning of the catalyst particle in the reforming machine 130 in the reforming machine 130, temperature does not fall too much by the specific downstream like the conventional reforming machine. Therefore, with the reforming vessel 130, it is maintained at the condition that the activity of a steam-reforming reaction is high, in the whole catalyst particle, and the speed of a steam-reforming reaction can be raised.

[0149] Drawing 21 is explanatory drawing which expressed the temperature-distribution condition inside [from an end side] an other end side about the reforming machine known conventionally [with the fixed flow direction of internal gas], and the reforming machine 130 mentioned above. Here, the gas supplied to the reforming machine 130 mixed the original fuel gas of the temperature of 250 degrees C, and flow rate 670 l/min, and the air of flow rate 140 l/min, and injected them in the reforming machine 130 from the injection nozzle 134 with five atmospheric pressures. Since unlike the conventional reforming machine oxidation reaction does not advance too much to a specific edge side and an internal catalyst particle is concerned with a reaction in the equal condition, the reforming machine 130 can equalize the internal temperature of a reforming machine in a 250-300-degree C temperature requirement. As explained above, since temperature does not rise rapidly near [the] the entry section, the reforming machine 130 of this example can prevent un-arranging [which it is called generating of the catalyst de-activation resulting from a temperature rise mentioned already, or a by-product]. Therefore, it becomes possible like the example mentioned already to raise the endurance of a reforming machine greatly.

[0150] In addition, although the original fuel gas containing air was used in the 6th example of the above as gas injected in the reforming machine 130 for churning, it is good also as using the gas which consists of any one at least among methanol gas, a steam, and air. In this case, what is necessary is just to suppose that the remaining components which were not used for injecting in a reforming machine for churning of a catalyst are supplied maintaining the condition that the catalyst particle was enclosed, to the inside of a reforming machine from the position (it is desirable that it is the upstream near the above-mentioned injection location) of a reforming machine.

[0151] Moreover, although the catalyst particle enclosed in the reforming machine 130 by injecting high-pressure gas in the reforming machine 130 is agitated in the 6th example of the above, it is good also as agitating a catalyst particle with means other than injection of gas. For example, it is good also as establishing the mechanical means which can agitate an internal catalyst particle in a reforming machine.

[0152] Next, the configuration to which the part to which the air with which oxidation reaction is presented is supplied is changed with time in the catalyst section as the 7th example is shown. Drawing 22 is explanatory drawing showing the configuration of the reforming machine 140 of the 7th example typically. The fuel cell equipment 20 of drawing 1 and the fuel cell equipment of the same configuration are equipped with this reforming machine 140. As shown in drawing 22, the reforming machine 140 equips the surface with the single reaction section 141 constituted by the honeycomb which supports a Cu-Zn catalyst, and is formed in it in the shape of a cylindrical shape. Moreover, the reforming machine 140 is pivotable by the predetermined motor which is not illustrated. Here, although the reforming machine 140 discharges the generated fuel gas to the 3rd fuel-supply way 65 like the example mentioned already while original fuel gas is supplied from the 2nd fuel-supply way 64, it has connected these 2nd fuel-supply way 64 and the 3rd fuel-supply way 65 to the abbreviation core of the cross section which carried out the approximate circle form of the reforming machine 140. By driving the above-mentioned motor, the reforming machine 140 rotates at the rate of per second 1 rotation centering on the core of the above-mentioned cross section.

[0153] Moreover, although air is supplied to it from the air supply way 39 while original fuel gas is supplied to the reforming machine 140 from the 2nd fuel-supply way 64, in this example, the edge by the side of connection with the

reforming machine 140 in this air supply way 39 is formed in the 2nd fuel-supply way 64. The edge of the air supply way 39 formed in the 2nd fuel-supply way 64 curves in the space established in the upstream of the reaction section 141 in the reforming machine 140, and is carrying out the opening as a diffuser 142 after that. This diffuser 142 meets the edge of the upstream of the reaction section 141, is carrying out the opening, and made that location that carries out a opening near middle with the circumference section of an edge cross section as well as the central point of the edge cross section of the reaction section 141 by this example. Air can be supplied to the cel of an abbreviation moiety focusing on the cel which is all over a diffuser 142 among each cel of the honeycomb which constitutes the reaction section 141 by blowing off the air supplied from the air supply way 39 from this diffuser 142.

[0154] Therefore, if the reforming machine 140 of this example is used, in the cel which receives supply of air from a diffuser 142, both a steam-reforming reaction and oxidation reaction will advance, and only a steam-reforming reaction will advance in the cel which does not receive supply of air. It rotates, as the reforming machine 140 was mentioned already at this time, and in order not to concern the location of a diffuser 142 with the condition of rotation of the reforming machine 140 and not to change, the cel which receives supply of air changes with time.

[0155] Since the cel which advances oxidation reaction in response to supply of air changes with time according to the reforming machine 140 of the 7th example constituted as mentioned above, in the upper section of a specific cel, temperature does not rise too much. Oxidation reaction advances in response to supply of air, in the cel in which the upstream cut only the temperature up, it will be in the condition of not receiving supply of air immediately, and oxidation reaction stops, and since the produced heat is consumed at a steam-reforming reaction, temperature does not rise any more. Moreover, in the cel in which heat was consumed by the steam reaction, without receiving supply of air, since air is supplied immediately and heat arises by oxidation reaction, temperature does not fall too much.

[0156] In addition, in the reforming machine 140, since the ratio of the amount of methanols and air content which are supplied becomes settled from the example mentioned already, the quantity of heat which the steam-reforming reaction which advances within a reforming machine takes similarly, and the quantity of heat produced in oxidation reaction, it is fixed. Here, with the reforming vessel 140 of this example, the cel which receives supply of air is always the abbreviation one half of the whole cel which constitutes a honeycomb. Therefore, in case each cel receives supply of air, the oxidation reaction which produces the heat more than the heat which takes the methanol which a superfluous quantity of oxygen will be supplied and was supplied rather than usual to carry out steam reforming occurs to the amount of methanols. However, as mentioned above, since supply of air is suspended immediately, as for these cels, temperature does not rise too much by the upstream to which air was supplied. Moreover, since air and original fuel gas are supplied in the condition with superfluous oxygen, the field where oxidation reaction occurs spreads even in the downstream more from the case where the oxygen of the usual concentration is supplied. Therefore, temperature does not fall too much by the downstream like the conventional reforming machine. Thus, with the reforming vessel 140, while maintaining the whole reaction section at a predetermined temperature requirement and maintaining the activity of a steam-reforming reaction at a high condition, the speed of a steam-reforming reaction can be raised.

[0157] Drawing 23 is explanatory drawing which took lessons from the whole cel which constitutes a honeycomb with the reforming machine known conventionally always supplies the oxygen of a predetermined rate, and the reforming machine 140 mentioned above, and expressed the temperature-distribution condition inside [from the upstream] the downstream with it. Measurement of this temperature-distribution condition was performed in the gas supplied to the reforming machine 140 in the conditions containing the air from which the ratio of LHSV(methanol volume / catalyst volume processed in 1 hour) = 3, and an oxygen/methanol becomes 11%, and the water with which the ratio of water/methanol is set to 2. Unlike the conventional reforming machine, temperature does not rise too much by the upstream and the reforming machine 140 can equalize the internal temperature of a reforming machine in a 250-300-degree C temperature requirement. Therefore, the reforming machine 140 of this example can prevent un-arranging [which it is called generating of the catalyst de-activation resulting from a temperature rise mentioned already or a by-product], and it becomes possible like the example mentioned already to raise the endurance of a reforming machine of it greatly. In addition, when fuel gas was generated using the reforming machine 140 in the above-mentioned conditions, $2 = 23\%$ of COs, and $H_2O = 17.5\%$, $2 = 9\%$ of N and the fuel gas used as $CO = 0.5\%$ were obtained, and operating good was confirmed $H_2 = 50\%$.

[0158] Although the reforming machine 140 of the 7th example explained above was considered as the configuration which the diffuser 142 with which air is supplied is fixed and the reforming machine 140 rotates, a diffuser can rotate and it can also be considered as the configuration to which the reforming machine was fixed. Such a reforming machine of a configuration is shown below as a modification of the 7th example. Drawing 24 is explanatory drawing which expresses typically the configuration of reforming machine 140A which is the modification of the 7th example. Reforming machine 140A is equipped with the almost same configuration as the reforming machine 140, and attaches

and explains Sign A to the same number at a corresponding member. Reforming machine 140A does not rotate in this reforming machine 140A. Moreover, the predetermined rolling mechanism 144 is formed in the bend which was prepared in the edge side which results in diffuser 142A in the air supply way 39 and which was mentioned already. By this rolling mechanism 144, the edge of the air supply way 39 equipped with diffuser 142A is rotated, and the field to which air is supplied from diffuser 142A changes with time in the upstream edge side of reaction section 141A.

[0159] Thus, also when using constituted reforming machine 140A, the same effect as the reforming machine 140 of the 7th example can be done so. In addition, the rolling mechanism 144 established near the edge of the air supply way 39 is considered as the configuration supported for the edge member 143 equipped with diffuser 142A, and the base of the air supply way 39, enabling free rotation, and the above-mentioned edge member 143 is good also as rotating according to the reaction force to which air blows off from diffuser 142A, and it is good also as generating turning effort using the predetermined power supplied from the outside.

[0160] In addition, what is necessary is to prepare two or more air supply openings in the upper section of a reforming machine, to be able to be good also as a configuration which changes with time air supply opening with which air is actually supplied, and just to be able to change with time the part to which air is supplied in the reaction section, although carried out to rotating either the diffuser of air or the reforming machines in the above-mentioned example. Moreover, although [the above-mentioned reforming machine 140 and reforming machine 140A] it has the reaction section constituted by the honeycomb, each reaction section may be constituted by being filled up with the pellet which supports a catalyst. Also in this case, the same effect as an example can be acquired by changing with time the part to which air is supplied in the reaction section.

[0161]

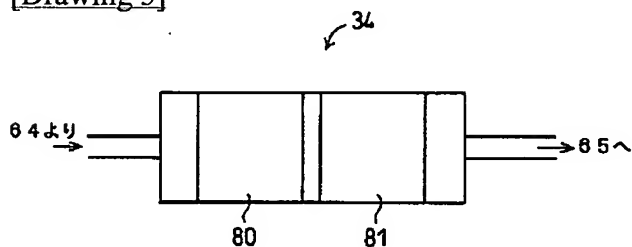
* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

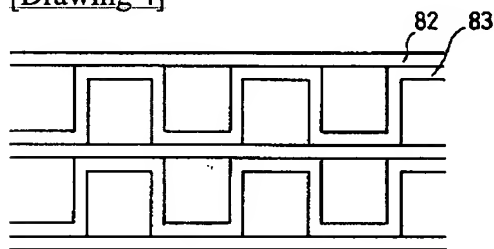
- 1.This document has been translated by computer. So the translation may not reflect the original precisely.
- 2.**** shows the word which can not be translated.
- 3.In the drawings, any words are not translated.

DRAWINGS

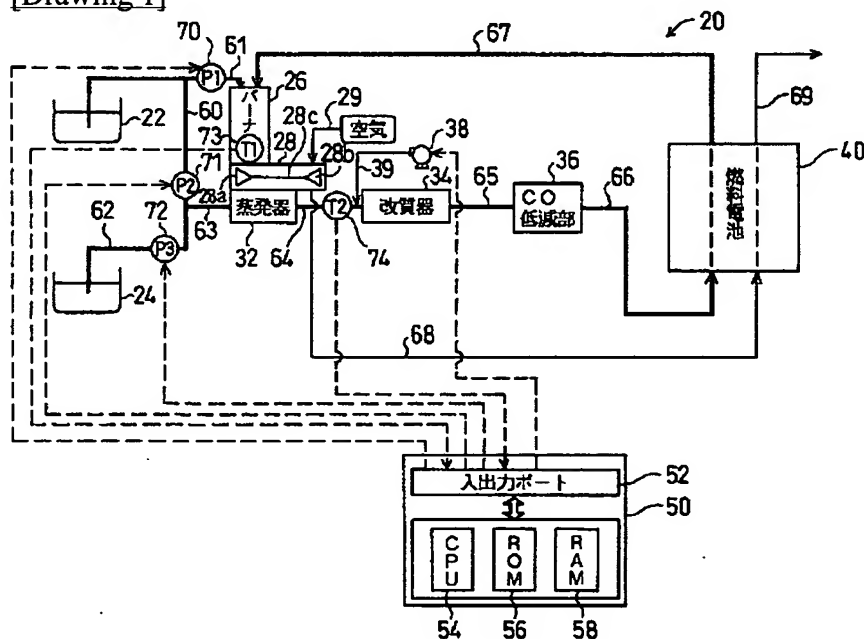
[Drawing 3]



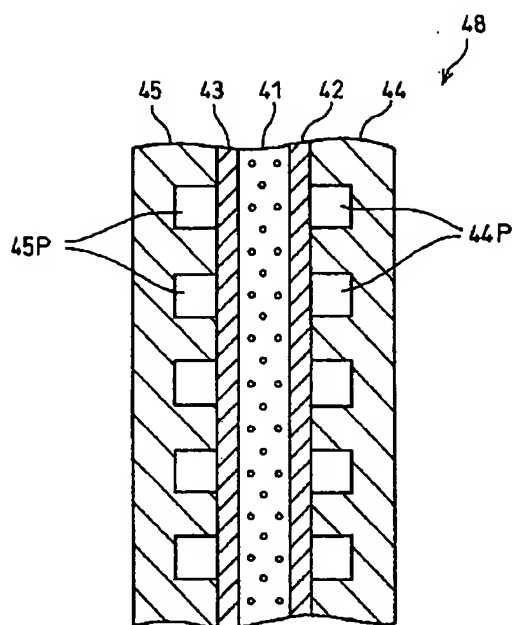
[Drawing 4]



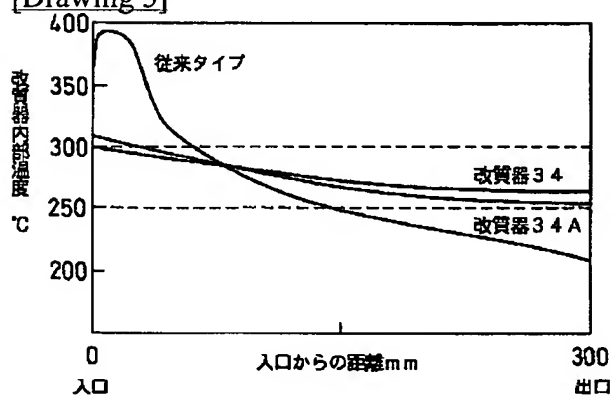
[Drawing 1]



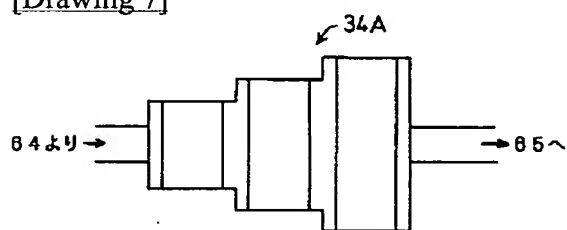
[Drawing 2]



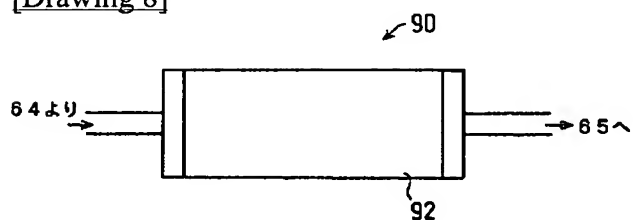
[Drawing 5]



[Drawing 7]

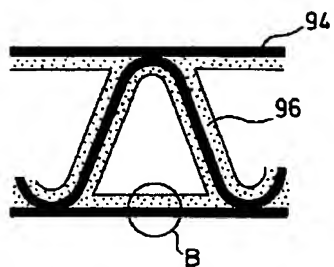


[Drawing 8]

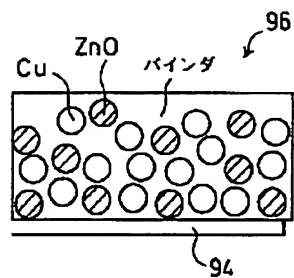


[Drawing 9]

(A)



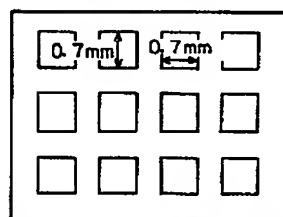
(B)



[Drawing 6]

(A)

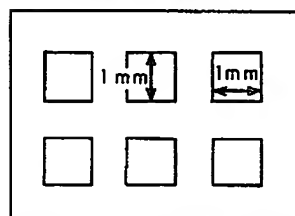
前段部 (セル面積小)



セラミックハニカム壁厚0.4mm

(B)

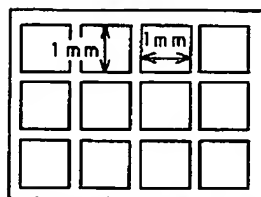
前段部 (セル数小)



セラミックハニカム壁厚0.7mm

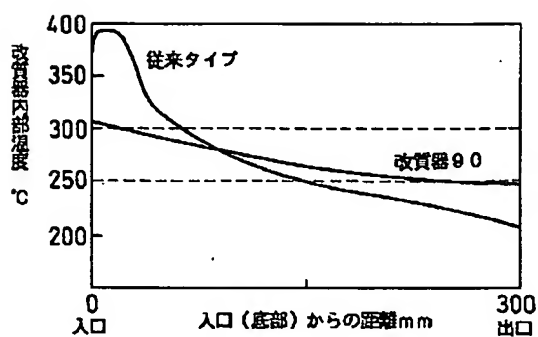
(C)

後段部

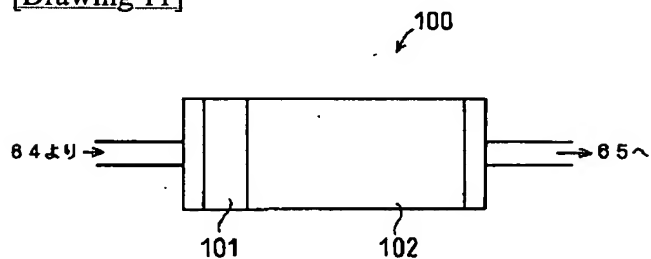


セラミックハニカム壁厚0.1mm

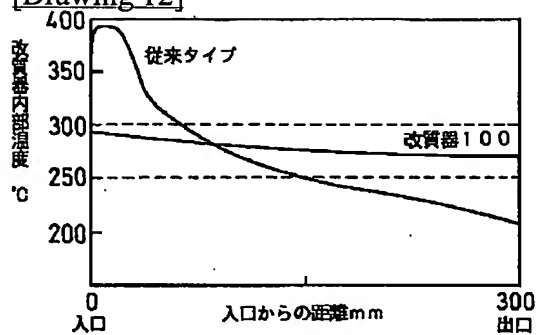
[Drawing 10]



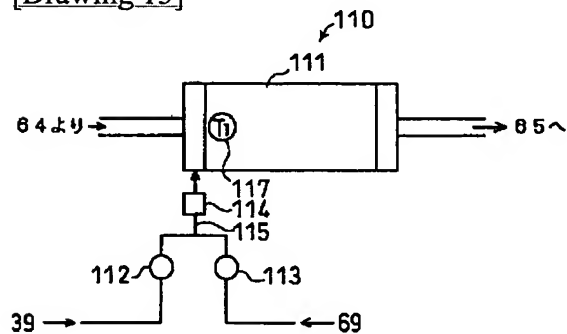
[Drawing 11]



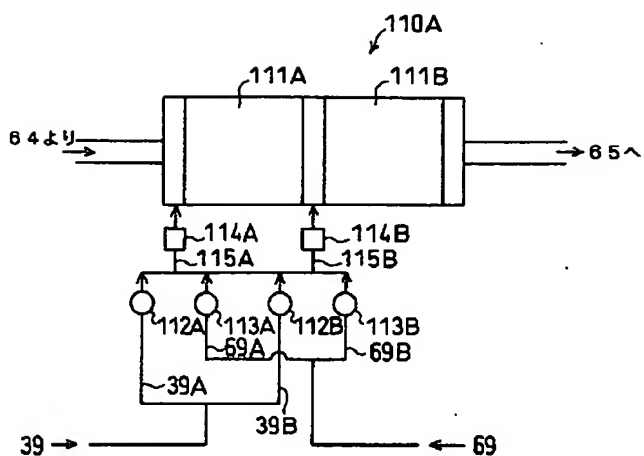
[Drawing 12]



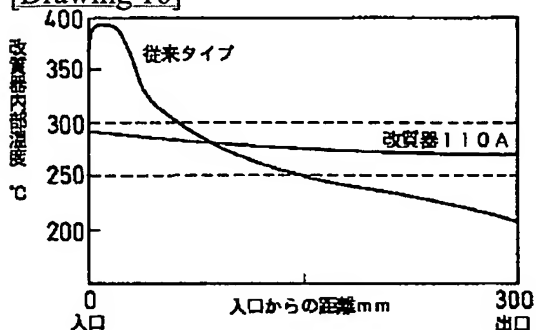
[Drawing 13]



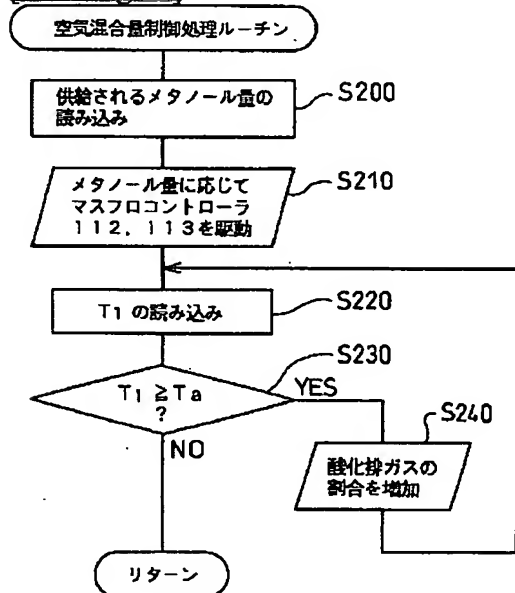
[Drawing 15]



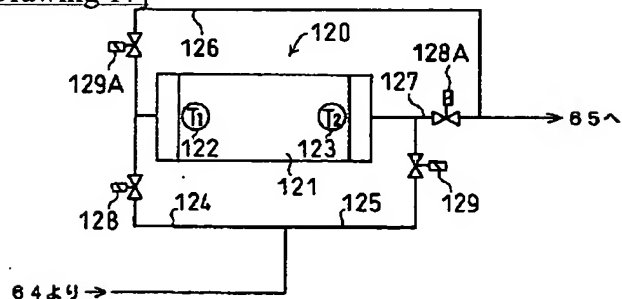
[Drawing 16]



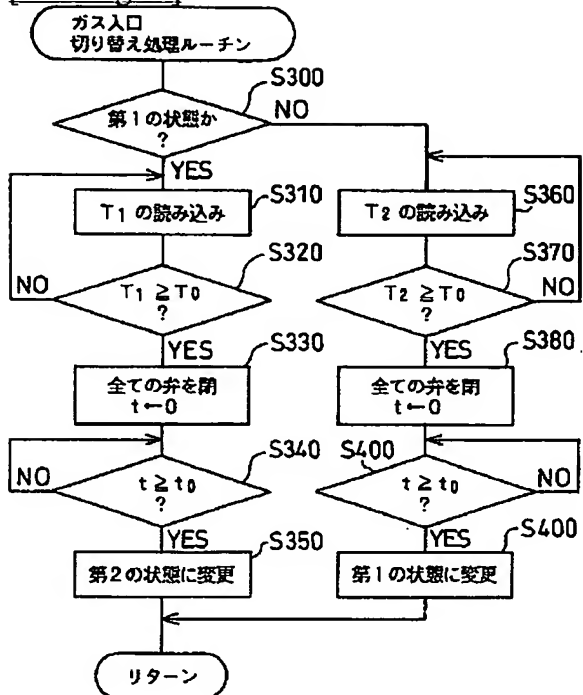
[Drawing 14]



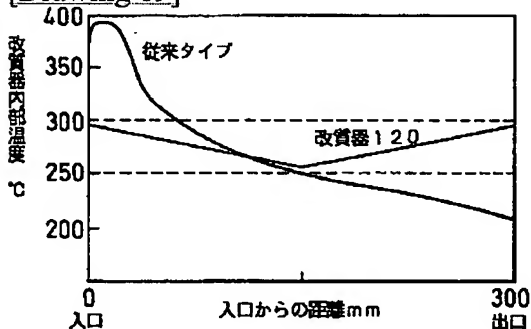
[Drawing 17]



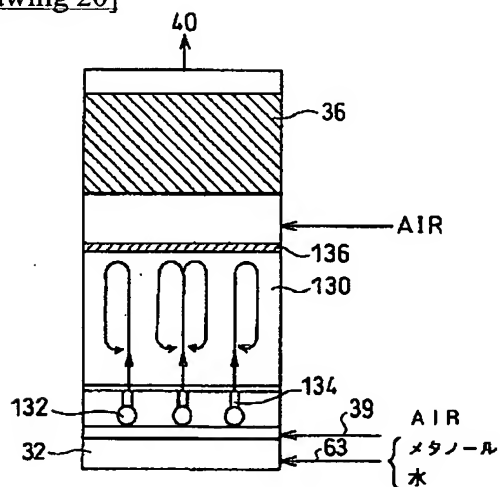
[Drawing 18]



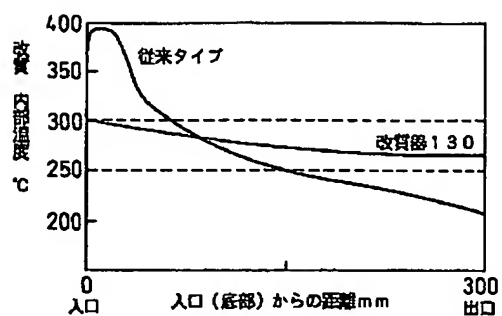
[Drawing 19]



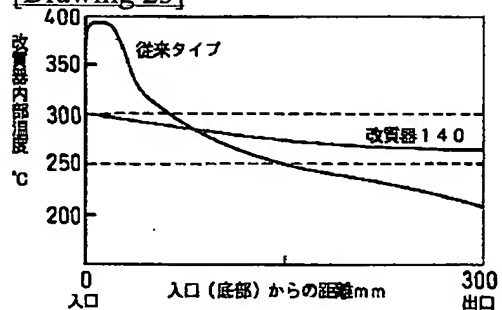
[Drawing 20]



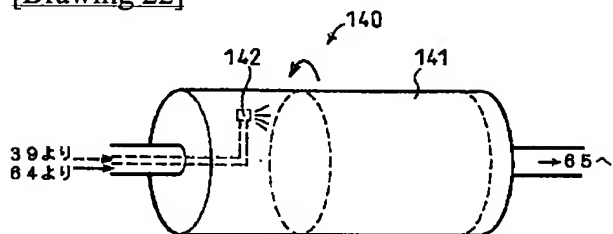
[Drawing 21]



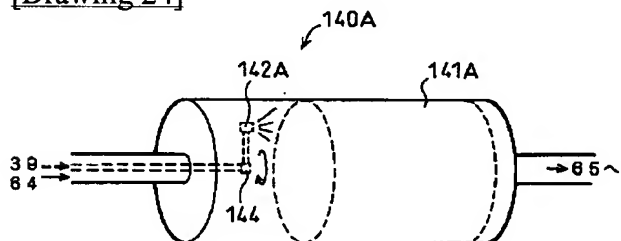
[Drawing 23]



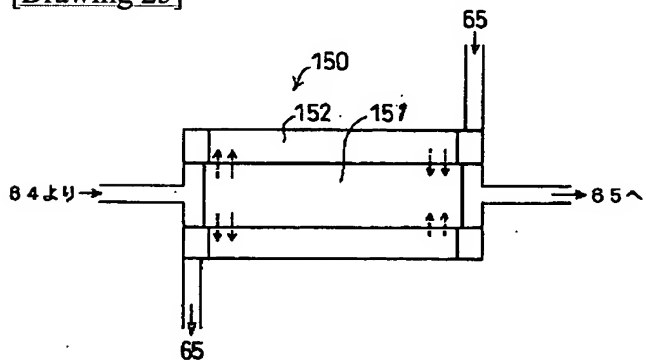
[Drawing 22]



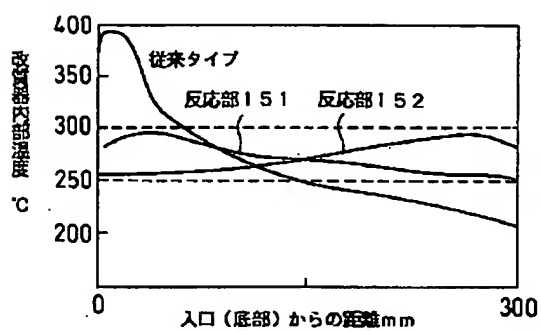
[Drawing 24]



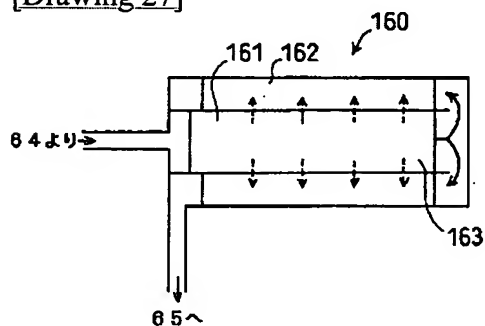
[Drawing 25]



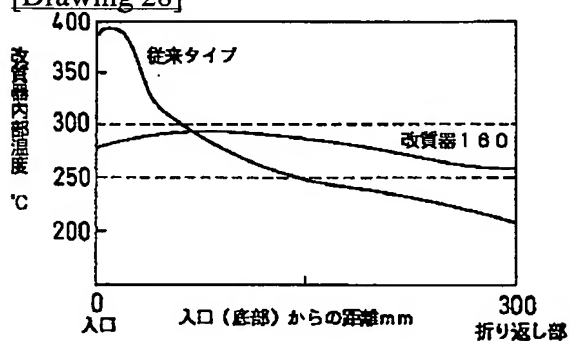
[Drawing 26]



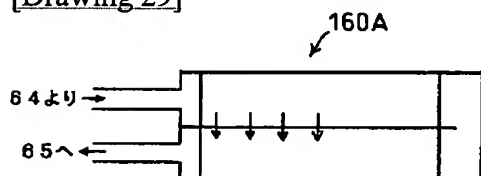
[Drawing 27]



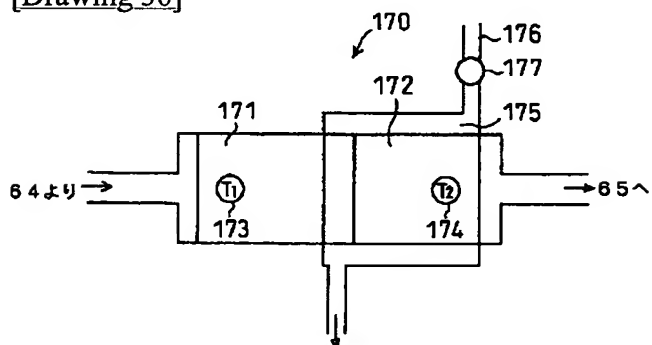
[Drawing 28]



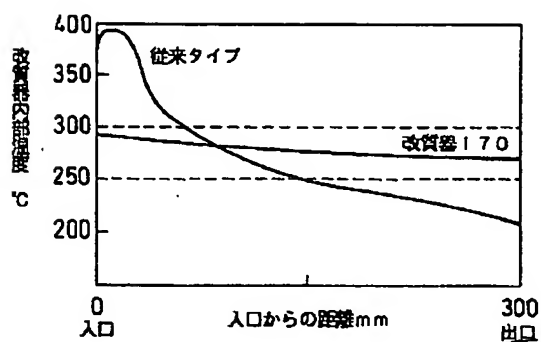
[Drawing 29]



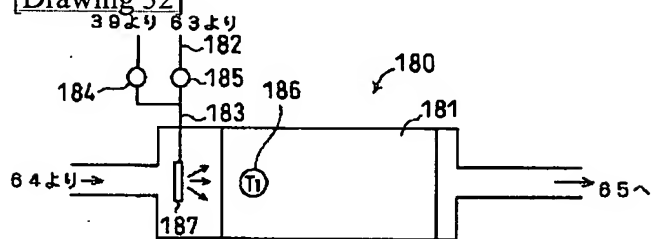
[Drawing 30]



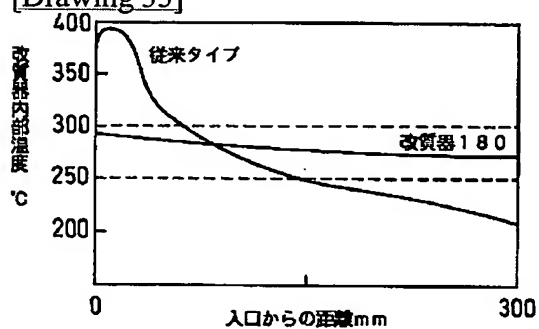
[Drawing 31]



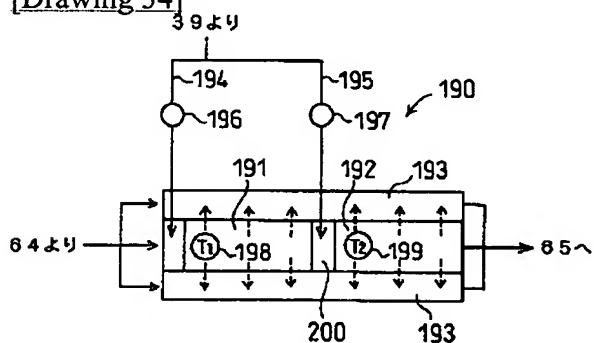
[Drawing 32]



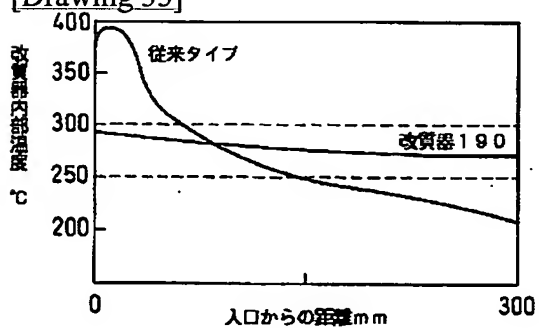
[Drawing 33]



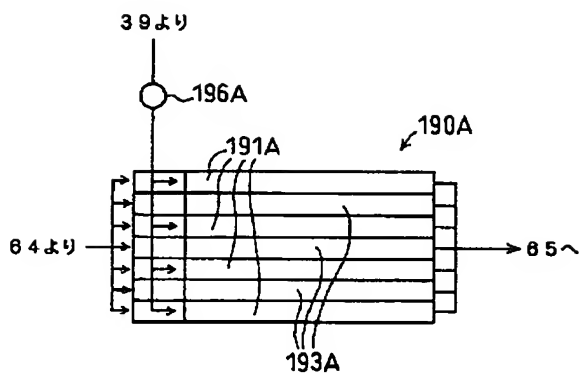
[Drawing 34]



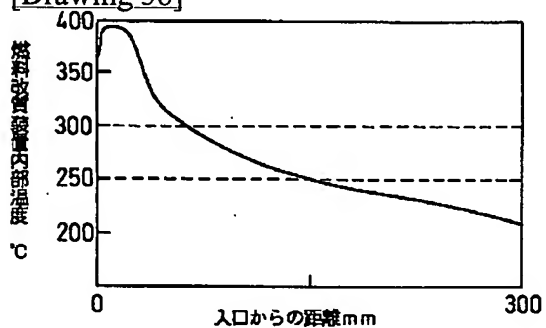
[Drawing 35]



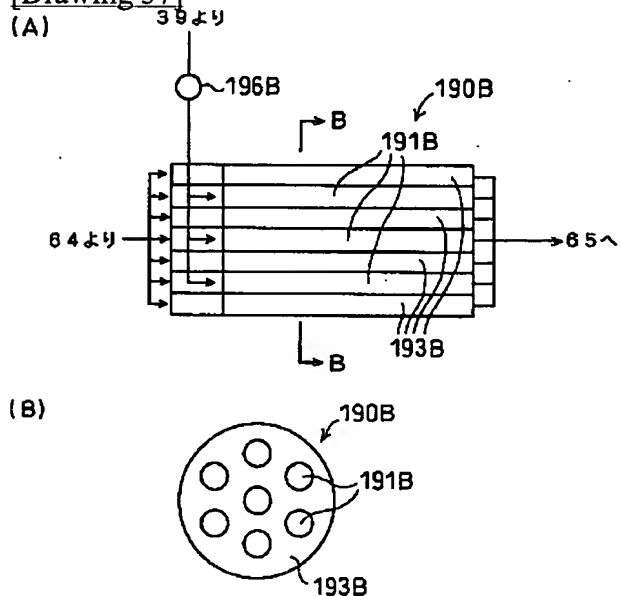
[Drawing 36]



[Drawing 38]



[Drawing 37]



[Translation done.]

(19) 日本国特許庁 (J P)

(12) 公開特許公報 (A)

(11) 特許出願公開番号

特開平11-92102

(43) 公開日 平成11年(1999) 4月6日

(51) Int.Cl.⁴

識別記号

F I

C 0 1 B 3/38

C 0 1 B 3/38

H 0 1 M 8/06

H 0 1 M 8/06

G

審査請求 未請求 請求項の数26 F D (全 40 頁)

(21) 出願番号 特願平10-210354

(22) 出願日 平成10年(1998) 7月8日

(31) 優先権主張番号 特願平9-214112

(32) 優先日 平9(1997) 7月23日

(33) 優先権主張国 日本 (J P)

(71) 出願人 000003207

トヨタ自動車株式会社

愛知県豊田市トヨタ町1番地

(72) 発明者 水野 誠司

愛知県豊田市トヨタ町1番地 トヨタ自動車株式会社内

(72) 発明者 尾崎 俊昭

愛知県豊田市トヨタ町1番地 トヨタ自動車株式会社内

(72) 発明者 川原 竜也

愛知県豊田市トヨタ町1番地 トヨタ自動車株式会社内

(74) 代理人 弁理士 下出 隆史 (外2名)

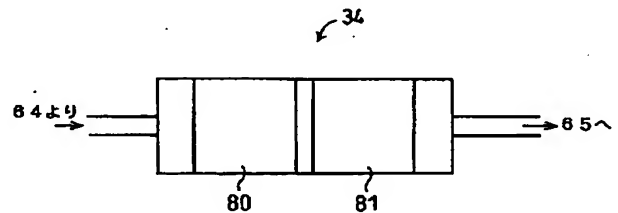
最終頁に続く

(54) 【発明の名称】 燃料改質装置

(57) 【要約】

【課題】 燃料電池装置の内部温度を所定の温度範囲内で均一化する。

【解決手段】 Cu-Zn触媒を備える改質器34は、第2燃料供給路64から、空気を含有する原燃料ガスの供給を受け、内部で水蒸気改質反応および酸化反応を進行させ、生じた水素リッチな燃料ガスを第3燃料供給路65へ排出する。改質器34は、上流側に位置する反応部80と、下流側に位置する反応部81とからなる。反応部80、81は、いずれもハニカムによって構成されているが、それぞれの反応部における流路断面積の総和、すなわち、それぞれのハニカムを構成する各セルの横断面積の総和は、上流側の反応部80の方が小さくなるように構成されている。したがって、改質器34内を通過するガスの流速は、上流側の方が下流側よりも速くなる。



【特許請求の範囲】

【請求項1】 吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気と酸素とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、前記触媒部において、前記原燃料ガスが供給される側の部分で起こる前記酸化反応で生じた熱が、充分に下流側に運ばれるように、前記原燃料ガスが導入される側の部分における前記原燃料ガスの流速を速くするガス流速調節手段とを備える燃料改質装置。

【請求項2】 前記ガス流速調節手段は、前記触媒部における前記原燃料ガスが供給される側において、前記燃料ガスが排出される側よりも、前記原燃料ガスが流れる流路の断面の総面積を小さくしてなる請求項1記載の燃料改質装置。

【請求項3】 吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気と酸素とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段とを備え、前記触媒部における前記触媒は、熱伝導性の比較的高い材料で形成される触媒担体に保持される燃料改質装置。

【請求項4】 請求項1ないし3いずれか記載の燃料改質装置であって、前記炭化水素はメタノールであり、前記水蒸気改質反応と前記酸化反応とを促進する触媒は、単一の銅系触媒である燃料改質装置。

【請求項5】 吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応を促進する触媒と前記酸化反応を促進する触媒とを備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気とを含有す

る原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部に対して、酸素を含有する酸化ガスを供給する酸化ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、前記触媒部における前記酸化ガスが導入される側において、前記酸化反応の進行を抑制する酸化反応抑制手段とを備える燃料改質装置。

10 【請求項6】 請求項5記載の燃料改質装置であって、前記酸化反応抑制手段は、前記触媒部において、前記酸化ガスが導入される側の方が、前記燃料ガスが排出される側よりも、前記酸化反応を促進する触媒の量が小となるように形成してなる燃料改質装置。

【請求項7】 請求項6記載の燃料改質装置であって、前記水蒸気改質反応を促進する触媒と前記酸化反応を促進する触媒とは同一の触媒であり、前記酸化反応抑制手段は、前記酸化ガスが導入される側の方が、前記燃料ガスが排出される側よりも、前記触媒の量が小となるように形成してなる燃料改質装置。

20 【請求項8】 吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応を促進する触媒と前記酸化反応を促進する触媒とを備える触媒部と、

前記触媒部に対して、前記炭化水素と水蒸気とを含有する原燃料ガスを供給する原燃料ガス供給手段と、30 前記触媒部に対して、酸素を含有する酸化ガスを供給する酸化ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、前記触媒部内で進行する反応の進行状態を検出する反応状態検出手段とを備え、前記酸化ガス供給手段は、前記触媒部に供給する単位時間当たりの酸素量を所望の量に維持しつつ、前記反応状態検出手段が検出した前記反応の進行状態に基づいて、前記触媒部に供給する前記酸化ガス中の酸素濃度を制御する酸素濃度調節手段をさらに備える燃料改質装置。

40 【請求項9】 請求項8記載の燃料改質装置であって、前記触媒部は、前記触媒を備える複数の反応部からなり、前記酸化ガス供給手段は、前記複数の反応部のそれぞれに対して前記酸化ガスを供給する燃料改質装置。

【請求項10】 請求項5ないし9いずれか記載の燃料改質装置であって、50 前記炭化水素はメタノールであり、

3

前記水蒸気改質反応を促進する触媒と前記酸化反応を促進する触媒とは同一の銅系触媒である燃料改質装置。

【請求項11】 吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える触媒部と、

前記触媒部に対して、前記炭化水素と水蒸気と酸素とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、

前記触媒部において、前記原燃料ガス供給手段から前記原燃料ガスを導入される部位と、前記燃料ガス排出手段によって前記燃料ガスを排出する部位とを入れ替え、前記触媒部におけるガスの流れを逆転させるガス供給方向変更手段とを備える燃料改質装置。

【請求項12】 請求項11記載の燃料改質装置であって、

前記触媒部において、前記原燃料ガス供給手段から前記原燃料ガスを供給される側の所定位置の温度を検出する端部温度検出手段をさらに備え、

前記ガス供給方向変更手段は、前記端部温度検出手段の検出結果に基づいて、前記原燃料ガス供給手段から前記原燃料ガスを導入される部位と、前記燃料ガス排出手段によって前記燃料ガスを排出する部位とを入れ替える燃料改質装置。

【請求項13】 吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える粒子を、内部に封入してなる触媒部と、前記触媒部に対して、前記炭化水素と水蒸気と酸素とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、前記触媒を備える粒子を、前記触媒部内で攪拌する触媒攪拌手段とを備える燃料改質装置。

【請求項14】 請求項13記載の燃料改質装置であって、

前記触媒攪拌手段は、前記原燃料ガス供給手段に備えられ、前記炭化水素と水蒸気と酸素とのうちの少なくとも一つを含有するガスを、前記触媒部内に噴霧して、前記触媒を備える粒子を前記触媒部内で攪拌する燃料改質装置。

4

【請求項15】 吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える触媒部と、

前記触媒部に対して、前記炭化水素と水蒸気とを含有する原燃料ガスを供給する原燃料ガス供給手段と、

10 前記触媒部に対して、酸素を含有する酸化ガスを供給する酸化ガス供給手段と、

前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、

前記触媒部において、前記酸化ガス供給手段から前記酸化ガスが供給される箇所を、経時的に変化させる供給箇所変更手段とを備える燃料改質装置。

【請求項16】 吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える触媒部と、

前記触媒部に対して、前記炭化水素と水蒸気とを含有する原燃料ガスを供給する原燃料ガス供給手段と、

前記触媒部に対して、酸素を含有する酸化ガスを供給する酸化ガス供給手段と、

30 前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、

前記触媒部において、前記原燃料ガスと共に酸化ガスが供給される供給側と、前記燃料ガスが排出される排出側とを隣接し、前記供給側と前記排出側との間で熱交換を行なわせる均熱化手段とを備える燃料改質装置。

【請求項17】 請求項16記載の燃料改質装置であって、

前記触媒部は、

各々内部に前記触媒を備え、各々の前記供給側と前記排出側とが互いに逆の位置にある少なくとも2つ以上の反応部を有し、

前記2つ以上の反応部を、一方の前記反応部の前記供給側と他方の前記供給部の前記排出側とを隣接して設ける燃料改質装置。

【請求項18】 前記触媒部は、内部に形成される前記原燃料ガスの流路において折り返し部を有し、前記流路の入り口部と出口部とを隣接して設ける請求項16記載の燃料改質装置。

50 【請求項19】 吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を

5

伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部に対して、酸素を含有する酸化ガスを供給する酸化ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、前記燃料改質装置を備えるシステムを構成する所定の部材において生じる熱を伝える所定の流体によって、前記酸化ガスが供給される側以外の部分を加熱する加熱手段とを備える燃料改質装置。

【請求項 20】 前記加熱手段は、前記燃料改質装置を備えるシステムを構成する所定の部材から排出される高温ガスによって、前記酸化ガスが供給される側以外の部分を加熱する請求項 19 記載の燃料改質装置。

【請求項 21】 吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部に対して、酸素を含有する酸化ガスを供給する酸化ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、前記炭化水素および水のうち少なくとも一方からなる液体を、前記原燃料ガスおよび前記酸化ガスが供給される側の部分に対して噴霧する端部冷却手段とを備える燃料改質装置。

【請求項 22】 請求項 11 ないし 21 いずれか記載の燃料改質装置であって、

前記炭化水素はメタノールであり、前記水蒸気改質反応と前記酸化反応とを促進する触媒は、単一の銅系触媒である燃料改質装置。

【請求項 23】 吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える第 1 の反応部と、前記水蒸気改質反応を促進する

6

触媒を備える第 2 の反応部とを備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記第 1 の反応部に対して、酸素を含有する酸化ガスを供給する酸化ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段とを備え、前記触媒部は、前記第 1 の反応部と前記第 2 の反応部とを隣接させ、前記第 1 の反応部と前記第 2 の反応部との間で熱交換を行なわせる燃料改質装置。

【請求項 24】 請求項 23 記載の燃料改質装置であって、

前記炭化水素はメタノールであり、前記第 1 の反応部が備える触媒は、単一の銅系触媒である燃料改質装置。

【請求項 25】 吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気と酸素とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段とを備え、前記触媒は、前記酸化反応として、一酸化炭素を生成する反応経路を経由しない反応を促進することを特徴とする燃料改質装置。

【請求項 26】 請求項 25 記載の燃料改質装置であって、

前記炭化水素はメタノールであり、前記水蒸気改質反応と前記酸化反応とを促進する触媒は、単一の銅系触媒である燃料改質装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、燃料改質装置に関し、詳しくは、炭化水素と水蒸気とから水素リッチガスを生成する燃料改質装置に関する。

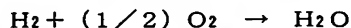
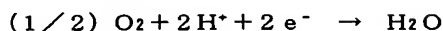
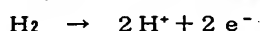
【0002】

【従来の技術】炭化水素と水蒸気とから水素リッチガスを生成する燃料改質装置は、燃料電池に燃料ガスを供給するための装置として知られている。燃料電池は、燃料の有する化学エネルギーを、機械エネルギーや熱エネルギーを経由することなく直接電気エネルギーに変換する装置であり、高いエネルギー効率が実現可能である。このような燃料電池は、水素を含有する燃料ガスを陰極側に供給され、酸素を含有する酸化ガスを陽極側に供給されて、両

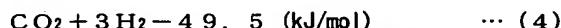
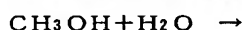
7

極で起きる電気化学反応によって起電力を得る。以下に、燃料電池で起こる電気化学反応を表わす式を示す。

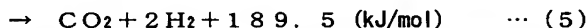
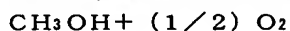
(1) 式は陰極側における反応、(2) 式は陽極側にお*



【0004】種々の燃料電池のうち、固体高分子型燃料電池、リン酸型燃料電池、熔融炭酸塩電解質型燃料電池などでは、その電解質の性質から、二酸化炭素を含んだ酸化ガスや燃料ガスを使用することが可能である。そこで、通常これらの燃料電池では、空気を酸化ガスとして用い、メタノールや天然ガス等の炭化水素を水蒸気改質して生成した水素リッチガスを燃料ガスとして用いている。そのため、このような燃料電池を備える燃料電池シ※



【0006】上記(4)式に示すように、水蒸気改質反応は吸熱反応であるため、改質反応を進行させるためには熱エネルギーを供給する必要がある。改質反応に要する熱エネルギーを供給する方法としては、燃料改質装置にバーナやヒータ等をつけて外部加熱を行なう方法や、燃料改質装置内部において、水蒸気改質反応に加えて発熱反★



【0008】上記(5)式は、メタノールの酸化反応の一例(部分酸化反応)を表わす。水蒸気改質反応を行なう燃料改質装置に対して酸素を供給し、(4)式に表わす水蒸気改質反応と共にメタノールの酸化反応を行なわせるならば、酸化反応で生じた熱エネルギーを、水蒸気改質反応において利用することができる。ここで、燃料改質装置に供給する酸素量を調節すれば、水蒸気改質反応で要する熱量と酸化反応で生じる熱量とを釣り合わせることができ、理論的には、水蒸気改質反応で要する熱量をすべて酸化反応で生じる熱量によって賄うことも可能となる。このような、水蒸気改質反応で要する熱量を酸化反応で生じる熱量によって賄う方法は、既述した外部加熱を行なう方法に比べて、放熱により失われるエネルギー量を減らすことができ、より高いエネルギー効率を実現することができる。さらに、外部加熱を行なう方法に比べて、燃料改質装置の構成を簡素化することができ、システム全体を小型化することができる。

【0009】

【発明が解決しようとする課題】しかしながら、燃料改質装置に対してメタノールや水蒸気と共に酸素を供給し、酸化反応によって生じた熱エネルギーを水蒸気改質反応で利用する上記した方法は、燃料改質装置の内部において、温度の分布状態が不均一となってしまうという問題があった。図38は、メタノールおよび水蒸気と共に酸素を燃料改質装置に供給し、水蒸気改質反応と共に酸化反応を行なうときの、燃料改質装置内部における温度

8

*ける反応を表わし、燃料電池全体では(3)式に示す反応が進行する。

【0003】



※システムには、上記した燃料改質装置が設けられており、この燃料改質装置において水蒸気改質反応を行なって燃料ガスを生成している。以下に、燃料改質装置の内部で進行する改質反応について説明する。ここでは、改質反応に供する炭化水素としてメタノールを用いる場合について説明する。以下に、メタノールを水蒸気改質する反応を表わす式を示す。

【0005】

★応である酸化反応を行なわせ、酸化反応で生じる熱を利用して水蒸気改質反応を進行させる方法などが知られている。これらの方法のうちで、燃料改質装置内部で水蒸気改質反応と共に酸化反応を進行させる方法について説明する。

【0007】

分布の様子を表わす説明図である。燃料改質装置に対して、メタノールおよび水蒸気と共に酸素を導入すると、水蒸気改質反応よりも酸化反応の方が反応速度が速いため、酸化反応で生じる熱量が水蒸気改質反応で要する熱量を上回り、図38に示すように、燃料改質装置における上流側(メタノール、水蒸気および酸素を含有するガスを導入する側)では、急激に内部温度が上昇して温度分布のピークを形成する。また、酸化反応で酸素が消費された後は水蒸気改質反応だけが進行するようになるため、上記した温度分布のピークの後は、燃料改質装置の内部温度は下流側(水素リッチガスが排出される側)に向かって下降を続ける。

【0010】燃料改質装置内部で温度分布がピークを形成し、温度が上昇しすぎる場合には、触媒が劣化したり副生成物が生じるなどの問題を生じる。まず、触媒の劣化について説明する。例えば、メタノールの水蒸気改質反応および酸化反応を促進する触媒としてCu-Zn触媒を用いる場合には、300℃を越える高温下でこのCu-Zn触媒を使用すると、触媒の耐久性が低下してシタリングを起こしてしまふおそれがある。ここでシタリングとは、担体表面に担持された触媒が凝集してしまふ現象をいう。Cu-Zn触媒は通常、亜鉛粒子の表面に銅微粒子が散在する形状をしているが、シタリングを起こすと銅微粒子が凝集して粒子が巨大化する。このような現象が生じると、銅粒子の表面積の低下に伴って触媒の活性面積が減少してしまふため燃料改質

装置の性能が低下してしまう。

【0011】また、触媒温度が上昇しすぎることによるもう一つの問題である副生成物の発生とは、所定の高温下で改質反応が進行する際に、既述した正常な反応以外の反応が起こり、メタンが生じたり、供給した加圧空気中の窒素ガスが反応して窒素酸化物が生じたりすることをいう。これらの副生成物は、燃料改質装置における改質反応温度の範囲では分解されることがなく、そのまま燃料ガスとして燃料電池に供給されてしまう。特にメタン等の生成量が増えることは燃料ガス中の水素分圧の低下につながり好ましくない。

【0012】一方、燃料改質装置の下流側において内部温度が低下すると、温度の低下と共に水蒸気改質反応の活性が低下するという問題を生じる。水蒸気改質反応の活性が低下してしまうと、改質反応の完了していないガス、すなわち、メタノールが残留して水素濃度が不十分なガスが生成されてしまうおそれがある。あるいは、下流側で内部温度が低下してしまっても改質反応が完了するように、十分に大きな燃料改質装置を備えることが必要になる。

【0013】本発明の燃料改質装置は、こうした問題を解決し、燃料改質装置の内部温度を所定の温度範囲内で均一化することを目的としてなされ、次の構成を採った。

【0014】

【課題を解決するための手段およびその作用・効果】本発明の第1の燃料改質装置は、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気と酸素とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、前記触媒部において、前記原燃料ガスが供給される側の部分で起こる前記酸化反応で生じた熱が、充分に下流側に運ばれるように、前記原燃料ガスが導入される側の部分における前記原燃料ガスの流速を速くするガス流速調節手段とを備えることを要旨とする。

【0015】以上のように構成された本発明の第1の燃料改質装置は、水蒸気改質反応と酸化反応とを促進する触媒を備える触媒部に対して、炭化水素と水蒸気と酸素とを含有する原燃料ガスを供給すると、この触媒部において、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行する。このとき、前記酸化反応で生じた熱を利用して前記水蒸

気改質反応が進行し、水素リッチな燃料ガスが生成されて前記触媒部から排出される。ここで、触媒部においては、前記原燃料ガスが供給される側の部分で起こる前記酸化反応で生じた熱が、充分に下流側に運ばれるように、前記原燃料ガスが導入される側の部分における前記原燃料ガスの流速が調節される。

【0016】このような燃料改質装置によれば、前記原燃料ガスが導入される側の部分で起こる酸化反応によって生じた熱が、充分に下流側に運ばれるため、前記原燃料ガスが導入される側の部分において温度が上昇しすぎてしまうことがない。したがって、温度が上昇しすぎることによる触媒劣化や副生成物の発生といった不都合が生じることがなく、改質器の耐久性を大きく向上させることができる。さらに、酸化反応で生じた熱が充分に下流側に運ばれることによって、下流側において、水蒸気改質反応の活性を充分に高くすることができ、燃料改質装置を小型化することが可能となる。

【0017】ここで、原燃料ガスを構成する炭化水素、水蒸気および酸素は、予めすべてを混合してから供給する必要はなく、少なくとも一つの成分あるいは原燃料ガスの一部は別個に供給することとしてもよい。予め混合しておかなくても、原燃料ガスを構成するこれらの成分が、触媒部におけるガスの流れの向きの上流側から供給されれば上記した効果を得ることができる。また、水蒸気改質反応を促進する触媒と酸化反応を促進する触媒とは、同一であっても良く、異なってもよい。すなわち、水蒸気改質反応と酸化反応とは、単一の触媒によって両反応が促進されることとしてもよいし、異なる触媒によってそれぞれの反応が促進されることとしてもよい。異なる触媒を用いる場合には、改質器内で両者が充分に混合されていることが望ましい。

【0018】上記本発明の第1の燃料改質装置において、前記ガス流速調節手段は、前記触媒部における前記原燃料ガスが供給される側において、前記燃料ガスが排出される側よりも、前記原燃料ガスが流れる流路の断面の総面積を小さくしてなることとしてもよい。このような構成とすることによって、前記原燃料ガスが供給される側における前記原燃料ガスの流速を、前記燃料ガスが排出される側よりも速くすることができ、上記した効果を得ることができる。

【0019】本発明の第2の燃料改質装置は、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気と酸素とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果

生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段とを備え、前記触媒部における前記触媒は、熱伝導性の比較的高い材料で形成される触媒担体に保持されることを要旨とする。

【0020】以上のように構成された本発明の第2の燃料改質装置は、水蒸気改質反応と酸化反応とを促進する触媒を備える触媒部に対して、炭化水素と水蒸気と酸素とを含有する原燃料ガスを供給すると、この触媒部において、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、生成した水素リッチな燃料ガスを排出する。ここで、前記触媒は、熱伝導性の比較的高い材料で形成される触媒担体に担持されるため、前記酸化反応で生じた熱は、触媒担体によって速やかに周辺部に伝えられ、前記水蒸気改質反応に利用される。

【0021】このような燃料改質装置によれば、酸化反応で生じた熱が速やかに拡散するため、前記原燃料ガスが供給される側であって、前記酸化反応が活発に進行する側において、温度が上昇しすぎてしまうことがない。したがって、温度が上昇しすぎることによる触媒劣化や副生成物の発生といった不都合が生じることがなく、改質器の耐久性を大きく向上させることができる。さらに、酸化反応で生じた熱が拡散されて下流側に伝えられることによって、下流側において、水蒸気改質反応の活性を十分に高くすることができ、燃料改質装置を小型化することが可能となる。

【0022】本発明の第3の燃料改質装置は、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応を促進する触媒と前記酸化反応を促進する触媒とを備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部に対して、酸素を含有する酸化ガスを供給する酸化ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、前記触媒部における前記酸化ガスが導入される側において、前記酸化反応の進行を抑制する酸化反応抑制手段とを備えることを要旨とする。

【0023】以上のように構成された本発明の第3の燃料改質装置は、水蒸気改質反応と酸化反応とを促進する触媒を備える触媒部に対して、炭化水素と水蒸気とを含有する原燃料ガスと、酸素を含有する酸化ガスを供給すると、この触媒部において、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化す

る酸化反応とを進行する。このとき、前記酸化反応で生じた熱を利用して前記水蒸気改質反応が進行し、水素リッチな燃料ガスが生成されて前記触媒部から排出される。ここで、触媒部においては、前記酸化ガスが導入される側において、前記酸化反応の進行が抑制される。

【0024】このような燃料改質装置によれば、前記酸化ガスが導入される側において、前記酸化反応の進行が抑制されるため、この前記酸化ガスが導入される側において温度が上昇しすぎてしまうことがない。したがって、温度が上昇しすぎることによる触媒劣化や副生成物の発生といった不都合が生じることがなく、改質器の耐久性を大きく向上させることができる。さらに、前記酸化ガスが導入される側で酸化反応の進行が抑制されることによって、酸化反応が進行する領域がより下流側に広がり、これによって下流側の温度を上昇させ、水蒸気改質反応の活性を十分に高くすることができる。したがって、燃料改質装置を小型化することが可能となる。

【0025】上記本発明の第3の燃料改質装置において、前記酸化反応抑制手段は、前記触媒部において、前記酸化ガスが導入される側の方が、前記燃料ガスが排出される側よりも、前記酸化反応を促進する触媒の量が小となるように形成してなることとしてもよい。

【0026】また、本発明の第3の燃料改質装置において、前記水蒸気改質反応を促進する触媒と前記酸化反応を促進する触媒とは同一の触媒であり、前記酸化反応抑制手段は、前記酸化ガスが導入される側の方が、前記燃料ガスが排出される側よりも、前記触媒の量が小となるように形成してなることとしてもよい。

【0027】本発明の第4の燃料改質装置は、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応を促進する触媒と前記酸化反応を促進する触媒とを備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部に対して、酸素を含有する酸化ガスを供給する酸化ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、前記触媒部内で進行する反応の進行状態を検出する反応状態検出手段とを備え、前記酸化ガス供給手段は、前記触媒部に供給する単位時間当たりの酸素量を所望の量に維持しつつ、前記反応状態検出手段が検出した前記反応の進行状態に基づいて、前記触媒部に供給する前記酸化ガス中の酸素濃度を制御する酸素濃度調節手段をさらに備えることを要旨とする。

【0028】以上のように構成された本発明の第4の燃料改質装置は、水蒸気改質反応と酸化反応とを促進する

触媒を備える触媒部に対して、炭化水素と水蒸気とを含有する原燃料ガスと、酸素を含有する酸化ガスとを供給すると、この触媒部において、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行する。このとき、前記酸化反応で生じた熱を利用して前記水蒸気改質反応が進行し、水素リッチな燃料ガスが生成されて前記触媒部から排出される。ここで、前記触媒部内で進行する反応の進行状態を検出し、前記触媒部に供給する単位時間当たりの酸素量を所望の量に維持しつつ、この検出した前記反応の進行状態に基づいて、前記触媒部に供給する前記酸化ガス中の酸素濃度を制御する。

【0029】このような燃料改質装置によれば、前記酸化ガス中の酸素濃度が制御されるため、酸化ガスが導入される側において進行する酸化反応の反応速度を制御することができ、この前記酸化ガスが導入される側において温度が上昇しすぎてしまうのを防止することができる。したがって、温度が上昇しすぎることによる触媒劣化や副生成物の発生といった不都合が生じることがなく、改質器の耐久性を大きく向上させることができる。さらに、酸化ガス中の酸素濃度を制御して酸化反応の反応速度を制御することによって、酸化反応が進行する領域をより下流側に広げることができ、これによって下流側の温度を上昇させ、水蒸気改質反応の活性を十分に高くすることができる。したがって、燃料改質装置を小型化することが可能となる。

【0030】上記した本発明の第4の燃料改質装置において、前記触媒部は、前記触媒を備える複数の反応部からなり、前記酸化ガス供給手段は、前記複数の反応部のそれぞれに対して前記酸化ガスを供給することとしてもよい。このような構成とすれば、酸化ガスが供給される箇所を複数にすることによって、触媒部内部の温度を均一化する効果をさらに高めることができる。

【0031】本発明の第5の燃料改質装置は、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気と酸素とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、前記触媒部において、前記原燃料ガス供給手段から前記原燃料ガスを導入される部位と、前記燃料ガス排出手段によって前記燃料ガスを排出する部位とを入れ替え、前記触媒部におけるガスの流れを逆転させるガス供給方向変更手段とを備えることを要

旨とする。

【0032】以上のように構成された本発明の第5の燃料改質装置は、水蒸気改質反応と酸化反応とを促進する触媒を備える触媒部に対して、炭化水素と水蒸気と酸素とを含有する原燃料ガスを供給すると、この触媒部において、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行する。このとき、前記酸化反応で生じた熱を利用して前記水蒸気改質反応が進行し、水素リッチな燃料ガスが生成されて前記触媒部から排出される。このような反応が進行する際に、前記触媒部において、前記原燃料ガスを導入される部位と、前記燃料ガスを排出する部位との入れ替えが行なわれる。

【0033】このような燃料改質装置によれば、前記触媒部において、前記原燃料ガスを導入される部位と、前記燃料ガスを排出する部位との入れ替えが行なわれるため、原燃料ガスが導入される特定の領域において、温度が上昇しすぎてしまうことがない。したがって、温度が上昇しすぎることによる触媒劣化や副生成物の発生といった不都合が生じることがなく、改質器の耐久性を大きく向上させることができる。さらに、特定の下流側において温度が低下してしまうことがなく、触媒部全体で水蒸気改質反応の活性を十分に高くすることができる。したがって、燃料改質装置を小型化することが可能となる。

【0034】上記した本発明の第5の燃料改質装置において、前記触媒部において、前記原燃料ガス供給手段から前記原燃料ガスを供給される側の所定位置の温度を検出する端部温度検出手段をさらに備え、前記ガス供給方向変更手段は、前記端部温度検出手段の検出結果に基づいて、前記原燃料ガス供給手段から前記原燃料ガスを導入される部位と、前記燃料ガス排出手段によって前記燃料ガスを排出する部位とを入れ替えることとしてもよい。このような構成とすることによって、原燃料ガスが供給される側において温度が上昇しすぎてしまうのを、確実に防止することができる。

【0035】本発明の第6の燃料改質装置は、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える粒子を、内部に封入してなる触媒部と、前記触媒部に対して、前記炭化水素と水蒸気と酸素とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、前記触媒を備える粒子を、前記触媒部内で攪拌する触媒攪

拌手段とを備えることを要旨とする。

【0036】以上のように構成された本発明の第6の燃料改質装置は、水蒸気改質反応と酸化反応とを促進する触媒を備える粒子を、内部に充填してなる触媒部に対して、炭化水素と水蒸気と酸素とを含有する原燃料ガスを供給する。その際、前記触媒部において、前記触媒を備える粒子を攪拌しながら、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行する。このとき、前記酸化反応で生じた熱を利用して前記水蒸気改質反応が進行し、水素リッチな燃料ガスが生成されて前記触媒部から排出される。

【0037】このような燃料改質装置によれば、前記触媒部において、前記触媒を備える粒子を攪拌するため、この粒子が備える触媒は、順次前記酸化反応に関わり、原燃料ガスが導入される特定の領域において温度が上昇しすぎてしまうことがない。したがって、温度が上昇しすぎることによる触媒劣化や副生成物の発生といった不都合が生じることがなく、改質器の耐久性を大きく向上させることができる。さらに、特定の下流側において温度が低下してしまうことがなく、触媒部全体で水蒸気改質反応の活性を十分に高くすることができる。したがって、燃料改質装置を小型化することが可能となる。

【0038】上記した本発明の第6の燃料改質装置において、前記触媒攪拌手段は、前記原燃料ガス供給手段に備えられ、前記炭化水素と水蒸気と酸素とのうちの少なくとも一つを含有するガスを、前記触媒部内に噴霧して、前記触媒を備える粒子を前記触媒部内で攪拌することとしてもよい。このような構成とすれば、前記触媒部に対して、前記原燃料を構成するガスを噴霧することによって攪拌の動作を同時に行なうことができる。

【0039】本発明の第7の燃料改質装置は、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部に対して、酸素を含有する酸化ガスを供給する酸化ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、前記触媒部において、前記酸化ガス供給手段から前記酸化ガスが供給される箇所を、経時的に変化させる供給箇所変更手段とを備えることを要旨とする。

【0040】以上のように構成された本発明の第7の燃料改質装置は、水蒸気改質反応と酸化反応とを促進する触媒を備える触媒部に対して、炭化水素と水蒸気とを

有する原燃料ガスと、酸素を含有する酸化ガスとを供給すると、この触媒部において、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行する。このとき、前記触媒部において、前記酸化ガスが供給される箇所は、経時的に変化させる。このようにして供給された酸化ガスを用いて進行する前記酸化反応で生じた熱を利用して、前記水蒸気改質反応が進行し、水素リッチな燃料ガスが生成されて前記触媒部から排出される。

【0041】このような燃料改質装置によれば、前記触媒部において、前記酸化ガスが供給される箇所が、経時的に変化させるため、酸化ガスが導入される特定の領域において、温度が上昇しすぎてしまうことがない。したがって、温度が上昇しすぎることによる触媒劣化や副生成物の発生といった不都合が生じることがなく、改質器の耐久性を大きく向上させることができる。

【0042】本発明の第8の燃料改質装置は、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部に対して、酸素を含有する酸化ガスを供給する酸化ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、前記触媒部において、前記原燃料ガスと共に酸化ガスが供給される供給側と、前記燃料ガスが排出される排出側とを隣接し、前記供給側と前記排出側との間で熱交換を行なわせる均熱化手段とを備えることを要旨とする。

【0043】以上のように構成された本発明の第8の燃料改質装置は、水蒸気改質反応と酸化反応とを促進する触媒を備える触媒部に対して、炭化水素と水蒸気とを含有する原燃料ガスと、酸素を含有する酸化ガスとを供給すると、この触媒部において、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行する。ここで、前記触媒部は、前記原燃料ガスと共に酸化ガスが供給される供給側と、前記燃料ガスが排出される排出側とを隣接して形成されているため、前記供給側と前記排出側との間で熱交換が行なわれ、前記酸化反応で生じた熱を利用して、前記水蒸気改質反応が進行し、水素リッチな燃料ガスが生成されて前記触媒部から排出される。

【0044】このような燃料改質装置によれば、前記触媒部において、前記原燃料ガスと共に酸化ガスが供給さ

17

れる供給側と、前記燃料ガスが排出される排出側との間で熱交換が行なわれるため、酸化ガスが導入される特定の領域において、温度が上昇しすぎてしまうことがない。したがって、温度が上昇しすぎることによる触媒劣化や副生成物の発生といった不都合が生じることがなく、改質器の耐久性を大きく向上させることができる。さらに、特定の下流側において温度が低下してしまうことがなく、触媒部全体で水蒸気改質反応の活性を十分に高くすることができる。したがって、燃料改質装置を小型化することが可能となる。

【0045】上記した本発明の第8の燃料改質装置において、前記触媒部は、各々内部に前記触媒を備え、各々の前記供給側と前記排出側とが互いに逆の位置にある少なくとも2つ以上の反応部を有し、前記2つ以上の反応部を、一方の前記反応部の前記供給側と他方の前記供給部の前記排出側とを隣接して設けてなることとしてもよい。

【0046】また、本発明の第8の燃料改質装置において、前記触媒部は、内部に形成される前記原燃料ガスの流路において折り返し部を有し、前記流路の入り口部と出口部とを隣接して設けてなることとしてもよい。

【0047】本発明の第9の燃料改質装置は、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部に対して、酸素を含有する酸化ガスを供給する酸化ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、前記燃料改質装置を備えるシステムを構成する所定の部材において生じる熱を伝える所定の流体によって、前記酸化ガスが供給される側以外の部分を加熱する加熱手段とを備えることを要旨とする。

【0048】以上のように構成された本発明の第9の燃料改質装置は、水蒸気改質反応と酸化反応とを促進する触媒を備える触媒部に対して、炭化水素と水蒸気とを含有する原燃料ガスと、酸素を含有する酸化ガスとを供給すると、この触媒部において、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行する。ここで、前記触媒部において、前記酸化ガスが供給されて前記酸化反応が行なわれる領域では、前記酸化反応で生じた熱を利用して、前記水蒸気改質反応が進行する。また、前記酸化ガスが供給される側以外の部分では、前記燃料改質装置を備えるシ

18

ステムを構成する所定の部材において生じる熱が、所定の流体によって伝えられ、この熱を利用して前記水蒸気改質反応が進行する。生成された水素リッチな燃料ガスは、前記触媒部から排出される。

【0049】このような燃料改質装置によれば、前記酸化ガスが供給される側以外の部分では、前記燃料改質装置を備えるシステムを構成する所定の部材において生じる熱を利用して前記酸化反応が進行するため、前記触媒部に供給する前記原燃料ガスの量に対して、前記触媒部に供給する前記酸化ガスの量を減らすことができ、前記酸化ガスが供給される側において、温度が上昇しすぎてしまうことがない。したがって、温度が上昇しすぎることによる触媒劣化や副生成物の発生といった不都合が生じることがなく、改質器の耐久性を大きく向上させることができる。さらに、前記酸化ガスが供給される側以外の部分では、前記燃料改質装置を備えるシステムを構成する所定の部材において生じる熱が伝えられるため、温度が低下することによって水蒸気改質反応の活性が低下してしまうことがない。したがって、触媒部全体で水蒸気改質反応の活性を十分に高くすることができ、燃料改質装置を小型化することが可能となる。また、前記燃料改質装置を備えるシステムを構成する所定の部材において生じる熱を利用するため、前記酸化ガスが供給される側以外の部分を加熱することによって、システム全体のエネルギー効率が低下してしまうこともない。

【0050】また、上記した本発明の第9の燃料改質装置において、前記加熱手段は、前記燃料改質装置を備えるシステムを構成する所定の部材から排出される高温ガスによって、前記酸化ガスが供給される側以外の部分を加熱することとしてもよい。

【0051】本発明の第10の燃料改質装置は、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部に対して、酸素を含有する酸化ガスを供給する酸化ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段と、前記炭化水素および水のうち少なくとも一方からなる液体を、前記原燃料ガスおよび前記酸化ガスが供給される側の部分に対して噴霧する端部冷却手段とを備えることを要旨とする。

【0052】以上のように構成された本発明の第10の燃料改質装置は、水蒸気改質反応と酸化反応とを促進する触媒を備える触媒部に対して、炭化水素と水蒸気とを

19

含有する原燃料ガスと、酸素を含有する酸化ガスとを供給すると、この触媒部において、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行する。ここで、前記触媒部において、前記酸化ガスが供給されて前記酸化反応が行なわれる領域では、前記酸化反応で生じた熱を利用して、前記水蒸気改質反応が進行するが、このとき、前記原燃料ガスおよび前記酸化ガスが供給される側の部分に対して、前記炭化水素および水のうち少なくとも一方からなる液体が噴霧され、前記液体が噴霧された部分が冷却される。生成された水素リッチな燃料ガスは、前記触媒部から排出される。

【0053】このような燃料改質装置によれば、前記原燃料ガスおよび前記酸化ガスが供給される側の部分では、前記炭化水素および水のうち少なくとも一方からなる液体が噴霧されるため、前記酸化反応によって生じた熱の一部が気化熱として消費され、前記酸化ガスが供給される側において温度が上昇しすぎてしまうことがない。したがって、温度が上昇しすぎることによる触媒劣化や副生成物の発生といった不都合が生じることがなく、改質器の耐久性を大きく向上させることができる。

【0054】本発明の第11の燃料改質装置は、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える第1の反応部と、前記水蒸気改質反応を促進する触媒を備える第2の反応部とを備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記第1の反応部に対して、酸素を含有する酸化ガスを供給する酸化ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出する燃料ガス排出手段とを備え、前記触媒部は、前記第1の反応部と前記第2の反応部とを隣接させ、前記第1の反応部と前記第2の反応部との間で熱交換を行なわせることを要旨とする。

【0055】以上のように構成された本発明の第11の燃料改質装置は、水蒸気改質反応と酸化反応とを促進する触媒を備える第1の反応部に対して、炭化水素と水蒸気とを含有する原燃料ガスと、酸素を含有する酸化ガスとを供給すると、この第1の反応部において、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行する。また、前記水蒸気改質反応を促進する触媒を備える第2の反応部に対して、前記原燃料ガスを供給すると、この第2の反応部におい

20

て、前記水蒸気改質反応を進行する。ここで、前記第1の反応部では、前記酸化反応で生じた熱を利用して、前記水蒸気改質反応が進行するが、前記第2の反応部も、隣接する前記第1の反応部と熱交換することによって、前記第1の反応部における前記酸化反応で生じた熱を利用して前記水蒸気改質反応が進行する。生成された水素リッチな燃料ガスは、前記触媒部から排出される。

【0056】このような燃料改質装置によれば、前記第1の反応部において、前記酸化ガスが供給されて前記酸化反応が進行する領域では、前記酸化反応によって生じた熱は、前記第1の反応部で進行する前記水蒸気改質反応に利用される他に、隣接する第2の反応部にも伝えられて、この第2の反応部で進行する前記水蒸気改質反応にも利用される。したがって、酸化反応で生じる熱によって前記触媒部の温度が上昇しすぎて、触媒劣化や副生成物の発生といった不都合が生じてしまうことがなく、改質器の耐久性を大きく向上させることができる。

【0057】ここで、本発明の第1または第2の燃料改質装置、あるいは、本発明の第5ないし第10の燃料改質装置において、前記炭化水素はメタノールであり、前記水蒸気改質反応と前記酸化反応とを促進する触媒は、単一の銅系触媒であることとしてもよい。

【0058】また、本発明の第3または第4の燃料改質装置において、前記炭化水素はメタノールであり、前記水蒸気改質反応を促進する触媒と前記酸化反応を促進する触媒とは同一の銅系触媒であることとしてもよい。

【0059】また、本発明の第11の燃料改質装置において、前記炭化水素はメタノールであり、前記第1の反応部が備える触媒は、単一の銅系触媒であることとしてもよい。

【0060】このような構成の燃料改質装置では、単一の銅系触媒によって、メタノールの水蒸気改質反応とメタノールの酸化反応とが促進される。銅系触媒によってメタノールの酸化反応を促進する場合には、白金など従来知られる他の酸化触媒を用いて酸化反応を促進する場合とは異なり、進行する酸化反応のほとんどは、一酸化炭素を生じない反応となる。したがって、このような構成とすることによって、より一酸化炭素濃度が低い燃料ガスを生成することができる。

【0061】本発明の第12の燃料改質装置は、吸熱を伴う反応であって、炭化水素と水蒸気とから水素を生成する水蒸気改質反応と、発熱を伴う反応であって前記炭化水素を酸化する酸化反応とを進行し、前記水蒸気改質反応を進行する際に、前記酸化反応で生じた熱を利用する燃料改質装置であって、前記水蒸気改質反応と前記酸化反応とを促進する触媒を備える触媒部と、前記触媒部に対して、前記炭化水素と水蒸気と酸素とを含有する原燃料ガスを供給する原燃料ガス供給手段と、前記触媒部で進行する前記水蒸気改質反応および前記酸化反応の結果生じた水素リッチな燃料ガスを、前記触媒部から排出

する燃料ガス排出手段とを備え、前記触媒は、前記酸化反応として、一酸化炭素を生成する反応経路を経由しない反応を促進することを要旨とする。

【0062】このような燃料改質装置によれば、前記触媒が、一酸化炭素を生成する反応経路を経由しない前記酸化反応を促進することができるため、触媒部内で進行する反応によって生じる一酸化炭素量を抑え、一酸化炭素濃度の低い燃料ガスを生成することができる。

【0063】本発明の第12の燃料改質装置において、前記炭化水素はメタノールであり、前記水蒸気改質反応と前記酸化反応とを促進する触媒は、単一の銅系触媒であることとしてもよい。

【0064】このような構成の燃料改質装置では、銅系触媒によってメタノールの酸化反応を促進するため、白金など従来知られる他の酸化触媒を用いて酸化反応を促進する場合とは異なり、進行する酸化反応のほとんどは、一酸化炭素を生じない反応となる。したがって、このような構成とすることによって、より一酸化炭素濃度が低い燃料ガスを生成することができる。また、単一の銅系触媒によって、メタノールの水蒸気改質反応とメタノールの酸化反応とが促進されるため、燃料改質装置の構成を簡素化することができる。

【0065】

【発明の実施の形態】以上説明した本発明の構成・作用を一層明らかにするために、以下本発明の実施の形態を実施例に基づき説明する。図1は、本発明の好適な第1実施例である改質器を備える燃料電池装置20の構成を例示する概略構成図である。燃料電池装置20は、メタノールを貯蔵するメタノールタンク22、水を貯蔵する水タンク24、燃焼ガスを発生するバーナ26、空気の圧縮を行なう圧縮機28、バーナ26と圧縮機28とを併設した蒸発器32、改質反応により燃料ガスを生成する改質器34、燃料ガス中の一酸化炭素(CO)濃度を低減するCO低減部36、電気化学反応により起電力を得る燃料電池40、コンピュータにより構成される制御部50を主な構成要素とする。まず最初に、燃料電池装置20における発電の主体である燃料電池40について説明する。

【0066】燃料電池40は、固体高分子電解質型の燃料電池であり、構成単位である単セルを複数積層したスタック構造を有している。図2は、燃料電池40を構成する単セル48の構成を例示する断面図である。単セル48は、電解質膜41と、カソード42およびアノード43と、セパレータ44、45とから構成されている。

【0067】カソード42およびアノード43は、電解質膜41を両側から挟んでサンドイッチ構造を成すガス拡散電極である。セパレータ44、45は、このサンドイッチ構造をさらに両側から挟みつつ、カソード42およびアノード43との間に、燃料ガスおよび酸化ガスの流路を形成する。カソード42とセパレータ44との間

には燃料ガス流路44Pが形成されており、アノード43とセパレータ45との間には酸化ガス流路45Pが形成されている。セパレータ44、45は、図2ではそれぞれ片面にのみ流路を形成しているが、実際にはその両面にリブが形成されており、片面はカソード42との間で燃料ガス流路44Pを形成し、他面は隣接する単セルが備えるアノード43との間で酸化ガス流路45Pを形成する。このように、セパレータ44、45は、ガス拡散電極との間でガス流路を形成するとともに、隣接する単セル間で燃料ガスと酸化ガスの流れを分離する役割を果たしている。もとより、単セル48を積層してスタック構造を形成する際、スタック構造の両端に位置する2枚のセパレータは、ガス拡散電極と接する片面にだけリブを形成することとしてもよい。

【0068】ここで、電解質膜41は、固体高分子材料、例えばフッ素系樹脂により形成されたプロトン伝導性のイオン交換膜であり、湿潤状態で良好な電気伝導性を示す。本実施例では、ナフィオン膜(デュボン社製)を使用した。電解質膜41の表面には、触媒としての白金または白金と他の金属からなる合金が担持されている。

【0069】カソード42およびアノード43は、共に炭素繊維からなる糸で織成したカーボクロスにより形成されている。なお、カソード42およびアノード43は、カーボクロスにより形成するほか、炭素繊維からなるカーボンペーパーまたはカーボンフェルトにより形成する構成も好適である。

【0070】セパレータ44、45は、ガス不透過の導電性部材、例えば、カーボンを圧縮してガス不透過とした緻密質カーボンにより形成されている。セパレータ44、45はその両面に、平行に配置された複数のリブを形成しており、既述したように、カソード42の表面とで燃料ガス流路44Pを形成し、隣接する単セルのアノード43の表面とで酸化ガス流路45Pを形成する。ここで、各セパレータの表面に形成されたリブは、両面ともに平行に形成する必要はなく、面毎に直行するなど所定の角度をなすこととしてもよい。また、リブの形状は平行な溝状である必要はなく、ガス拡散電極に対して燃料ガスまたは酸化ガスを供給可能であればよい。

【0071】以上、燃料電池40の基本構造である単セル48の構成について説明した。実際に燃料電池40として組み立てるときには、セパレータ44、カソード42、電解質膜41、アノード43、セパレータ45の順序で構成される単セル48を複数組積層し(本実施例では100組)、その両端に緻密質カーボンや銅板などにより形成される集電板を配置することによって、スタック構造を構成する。

【0072】以下、燃料電池装置20を構成する燃料電池40以外の構成要素およびそれらの接続関係について順次説明する。蒸発器32は、メタノールタンク22お

よび水タンク 24 からメタノールと水の供給を受け、これらメタノールと水とを気化させる装置である。蒸発器 32 は、既述したようにバーナ 26 と圧縮機 28 とを併設しているが、後述するように圧縮機 28 を介してバーナ 26 の燃焼排ガスが導かれ、この燃焼熱が蒸発器 32 の備える図示しない熱交換器に伝えられて、蒸発器 32 に供給されたメタノールと水とを沸騰、気化させる。

【0073】メタノールタンク 22 から蒸発器 32 に原料燃料であるメタノールを送り込むメタノール流路 60 には第 2 ポンプ 71 が設けられており、蒸発器 32 に供給するメタノール量を調節可能となっている。この第 2 ポンプ 71 は、制御部 50 に接続されており、制御部 50 から出力される信号によって駆動され、蒸発器 32 に供給するメタノール流量を調節する。

【0074】水タンク 24 から蒸発器 32 に水を送り込む水供給路 62 には第 3 ポンプ 72 が設けられており、蒸発器 32 に供給する水の量を調節可能となっている。この第 3 ポンプ 72 は、第 2 ポンプ 71 と同じく制御部 50 に接続されており、制御部 50 から出力される信号によって駆動され、蒸発器 32 に供給する水量を調節する。上記メタノール流路 60 と水供給路 62 とは合流して第 1 燃料供給路 63 を形成し、この第 1 燃料供給路 63 は蒸発器 32 に接続する。メタノール流量と水量とは上記第 2 ポンプ 71 と第 3 ポンプ 72 とによって調節されるため、所定量ずつ混合されたメタノールと水とは第 1 燃料供給路 63 を介して蒸発器 32 に供給される。

【0075】蒸発器 32 に併設された圧縮機 28 は、燃料電池装置 20 の外部から空気を取り込んでこれを圧縮し、この圧縮空気を燃料電池 40 の陽極側に供給するための装置である。圧縮機 28 は、タービン 28 a およびコンプレッサ 28 b を備え、これらは羽根車型に形成されている。タービン 28 a およびコンプレッサ 28 b は同軸上のシャフト 28 c で連結されており、タービン 28 a を回転駆動することにより、コンプレッサ 28 b を回転駆動することができる。蒸発器 32 にはさらにバーナ 26 が併設されているが、このバーナ 26 から的高温の燃焼ガスによってタービン 28 a は駆動される。タービン 28 a の回転と共にコンプレッサ 28 b も回転し、このコンプレッサ 28 b は、既述したように空気の圧縮を行なう。コンプレッサ 28 b へは、空気導入路 29 を介して外部から空気を取り込み可能となっており、圧縮機 28 で圧縮された空気は、酸化ガス供給路 68 を介して燃料電池 40 に供給され、燃料電池 40 における電気化学反応に供される。

【0076】ここで、タービン 28 a は、バーナ 26 からの高温の燃焼ガスにより駆動されるので、耐熱性および耐久性を実現するために超耐熱合金やセラミックス等により形成される。本実施例では、ニッケルベースの合金（インコネル 700、インコネル社）を使用した。また、コンプレッサ 28 b は、軽量なアルミニウム合金に

より形成される。

【0077】タービン 28 a を駆動するバーナ 26 は、燃焼のための燃料を、燃料電池 40 の陰極側およびメタノールタンク 22 から供給される。燃料電池 40 は、メタノールを改質器 34 で改質して生成した水素リッチガスを燃料として電気化学反応を行なうが、燃料電池 40 に供給されたすべての水素が電気化学反応において消費されるわけではなく、消費されずに残った水素を含む燃料排ガスは燃料排出路 67 に排出される。バーナ 26 は、この燃料排出路 67 に接続して燃料排ガスの供給を受け、消費されずに残った水素を完全燃焼させて燃料の利用効率の向上を図っている。通常はこのような排燃料だけではバーナ 26 における燃焼反応のための燃料として不足するため、この不足分に相当する燃料、および燃料電池装置 20 の起動時のように燃料電池 40 から排燃料の供給を受けられないときの、バーナ 26 における燃焼反応のための燃料は、メタノールタンク 22 からバーナ 26 に対して供給される。バーナ 26 へメタノールを供給するためにメタノール分岐路 61 が設けられている。このメタノール分岐路 61 は、メタノールタンク 22 から蒸発器 32 にメタノールを供給するメタノール流路 60 から分岐している。

【0078】ここで、バーナ 26 には第 1 温度センサ 73 が設けられており、バーナ 26 での燃焼熱の温度を測定して、この測定結果を制御部 50 に入力している。制御部 50 は、この第 1 温度センサ 73 からの入力結果を基に、第 1 ポンプ 70 に駆動信号を出力して、バーナ 26 に供給するメタノール量を調節し、バーナ 26 での燃焼温度を所定の範囲（約 800℃ から 1000℃）に保っている。このバーナ 26 における燃焼ガスは、タービン 28 a を回転駆動したのち蒸発器 32 に導かれる。タービン 28 a での熱交換効率は余り高くないため（約 10% 以内）、蒸発器 32 に導かれる燃焼排ガスの温度は約 600℃ ～ 700℃ に達し、蒸発器 32 の熱源として充分となる。ここで、既述した第 1 燃料供給路 63 を介して供給されたメタノールと水との混合溶液は、蒸発器 32 に導かれたバーナ 26 の高温燃焼排ガスによって気化させる。蒸発器 32 で気化されたメタノールと水とからなる原燃料ガスは、第 2 燃料供給路 64 に導かれて改質器 34 に伝えられる。

【0079】改質器 34 は、供給されたメタノールと水とからなる原燃料ガスを改質して水素リッチな燃料ガスを生成する。この改質器 34 の構成および改質器 34 で行なわれる改質反応は本発明の要部に対応するものであり、後に詳述する。なお、改質器 34 にメタノールと水とからなる原燃料ガスを供給する第 2 燃料供給路 64 には、第 2 温度センサ 74 が設けられており、改質器 34 に供給されるメタノールと水とからなる原燃料ガスの温度を測定している。この原燃料ガスの温度に関する測定結果は、制御部 50 に入力される。制御部 50 は、既述

25

した第1温度センサ73からの入力結果に基づいて第1ポンプ70に駆動信号を出力する際に、この第2温度センサ74からの信号を基にして、上記第1ポンプ70の駆動量を補正し、バーナ26に供給するメタノール量を調節する。このようにしてバーナ26での燃焼ガスの温度を制御することによって、蒸発器32で気化された上記原燃料ガスの温度を調節する。蒸発器32から供給される原燃料ガスは、通常約250℃に昇温している。

【0080】また、後述するように改質器34における改質反応では酸素が関与するが、この改質反応に必要な酸素を供給するために、改質器34にはブロウ38が併設されている。ブロウ38は、外部から空気を取り込んでこれを圧縮し、取り込んだ空気を空気供給路39を介して改質器34に供給する。本実施例では、空気供給路39は第2燃料供給路64に接続しており、ブロウ38が取り込んだ空気は、蒸発器32から供給される原燃料ガスと共に改質器34に供給される。ブロウ38は制御部50に接続されており、制御部50によってその駆動状態が制御される。

【0081】CO低減部36は、第3燃料供給路65を介して改質器34から供給された燃料ガス中の一酸化炭素濃度を低減させる装置である。メタノールの一般的な改質反応はすでに(4)式に示したが、実際に改質反応が行なわれるときにはこれらの式に表わしたように理想的に反応が進行するわけではなく、改質器34で生成された燃料ガスは所定量の一酸化炭素を含んでいる。そこで、CO低減部36を設けることで、燃料電池40に供給する燃料ガス中の一酸化炭素濃度の低減を図っている。

【0082】本実施例の燃料電池40は固体高分子型の燃料電池であって、電池反応を促進する白金または白金と他の金属とからなる触媒を備えているが(本実施例では白金触媒を電解質膜41の表面に塗布した)、燃料ガス中に一酸化炭素が含まれる場合には、この一酸化炭素が白金触媒に吸着して触媒としての機能を低下させ、

(1)式に示したアノードにおける反応を阻害して燃料電池の性能を低下させてしまう。そのため、燃料電池40のような固体高分子型の燃料電池を用いて発電を行なうためには、供給する燃料ガス中の一酸化炭素濃度を所定量以下に低減して電池性能の低下を防ぐことが必須となる。なお、このような固体高分子型燃料電池において、供給される燃料ガス中の一酸化炭素濃度としての許容濃度は、通常は数ppm程度以下である。

【0083】CO低減部36に供給される燃料ガスは、上記したように所定量の一酸化炭素を含有する水素リッチガスであり、CO低減部36においては、燃料ガス中の水素に優先して一酸化炭素の酸化が行なわれる。CO低減部36には、一酸化炭素の選択酸化触媒である白金触媒、ルテニウム触媒、パラジウム触媒、金触媒、あるいはこれらを第1元素とした合金触媒を担持した担体が

26

充填されている。このCO低減部36で処理された燃料ガス中の一酸化炭素濃度は、CO低減部36の運転温度、供給される燃料ガス中の一酸化炭素濃度、CO低減部36への単位触媒体積当たりの燃料ガスの供給流量等によって定まる。CO低減部36には図示しない一酸化炭素濃度センサが設けられており、この測定結果に基づいてCO低減部36の運転温度や供給する燃料ガス流量を調節し、処理後の燃料ガス中の一酸化炭素濃度が数ppm以下となるように制御している。

【0084】CO低減部36で上記のように一酸化炭素濃度が下げられた燃料ガスは、第4燃料供給路66によって燃料電池40に導かれ、陰極側における電池反応に供される。燃料電池40で電池反応に用いられた後の燃料排ガスは、既述したように燃料排出路67に排出されてバーナ26に導かれ、この燃料排ガス中に残っている水素が燃焼のための燃料として消費される。一方、燃料電池40の陽極側における電池反応に関わる酸化ガスは、既述したように、圧縮機28から酸化ガス供給路68を介して圧縮空気として供給される。電池反応に用いられた残りの酸化排ガスは、酸化排ガス路69を介して外部に排出される。

【0085】制御部50は、マイクロコンピュータを中心とした論理回路として構成され、詳しくは、予め設定された制御プログラムに従って所定の演算などを実行するCPU54と、CPU54で各種演算処理を実行するのに必要な制御プログラムや制御データ等が予め格納されたROM56と、同じくCPU54で各種演算処理をするのに必要な各種データが一時的に読み書きされるRAM58と、既述した各種温度センサからの検出信号を入力すると共にCPU54での演算結果に応じて既述した各種ポンプやブロウ38などに駆動信号を出力する入出力ポート52等を備える。

【0086】次に、本発明の要部に対応する改質器34の構成について説明する。図3は、改質器34の構成の概略を模式的に表わす説明図である。本実施例の改質器34は、第2燃料供給路64に接続する側の端部より原燃料ガスおよび空気の供給を受け、これら原燃料ガスおよび空気は、改質器34の内部を通過しながら水蒸気改質反応および酸化反応(部分酸化反応)に供される。改質器34内において、(4)式に示す水蒸気改質反応および(5)式に示す酸化反応によって生成された水素リッチな燃料ガスは、もう一方の端部より第3燃料供給路65に排出される。この改質器34は、その内部に、第1反応部80および第2反応部81を備えている。これら第1反応部80および第2反応部81は、表面にCu-Zn触媒を担持したメタルハニカムとして構成されており、上流側(第2燃料供給路64との接続部に近い側)に形成された第1反応部80は、下流側(第3燃料供給路65との接続部に近い側)に形成された第2反応部81よりも、後述するセル数が少なくなるように形成

されている。

【0087】図4は、第1反応部80および第2反応部81を形成するメタルハニカムの横断面の一部を表わす模式図である。メタルハニカムは、ステンレス板82、83を積層して形成されている。すなわち、平板状のステンレス板82と、波状に折り曲げたステンレス板83とを交互に配設して、メタルハニカムは形成されている。ステンレス板83は、1mm間隔で波状に折り曲げられているため、このステンレス板83と平板状のステンレス板82とを交互に積層することで、1辺の長さが1mmである略正方形の断面を有するセルからなるハニカムを形成することができる。

【0088】ここで、第1反応部80と第2反応部81とでは、メタルハニカムを形成するために用いたステンレス板82、83の厚みが異なっており、これによって、第1反応部80と第2反応部81とは、それぞれが備えるセル数が異なって形成される。第1反応部80は、厚さが0.1mmのステンレス板82、83によって形成されたハニカムからなり、第2反応部81は、厚さが0.03mmのステンレス板82、83によって形成されるハニカムからなる。したがって、第1反応部80は、その断面積1cm²あたり約75個のセルを備え、第2反応部81は、同じく1cm²あたり約91個のセルを備えることになる。改質器34全体では断面積は一定であるため、上記したように厚みの異なるステンレス板によってハニカムを構成することによって、第1反応部80におけるガス流路の断面の総面積（第1反応部80を構成する各セルの断面積の総和）は、第2反応部81におけるガス流路の断面の総面積（第2反応部81を構成する各セルの断面積の総和）よりも小さくなる。

【0089】第1反応部80および第2反応部81は、それぞれを構成するハニカム表面に触媒を担持しているため、上流側から原燃料ガスを供給すると、原燃料ガスは、上記ハニカム表面を通過する間に水蒸気改質反応および酸化反応に供されて水素リッチな燃料ガスとなる。本実施例では、ハニカム表面に担持させる触媒は、銅と酸化亜鉛とを用いて共沈法によって製造した。共沈法によって得たCu-Zn触媒は、これを粉碎してさらにアルミナゾル等のバインダを加え、ハニカム上に塗布する等の方法により、ハニカム上に担持させることができる。

【0090】以上のように構成された改質器34に原燃料ガスを供給すると、原燃料ガスは、まず、セル数の少ない、すなわちガス流路断面の総面積が小さい第1反応部80内を通過し、次に、セル数の多い、すなわちガス流路断面の総面積が大きい第2反応部81内を通過する。このように、所定量の原燃料ガスが、ガス流路断面の総面積が小さいハニカム内を通過した後、ガス流路断面の総面積が大きいハニカム内を通過するため、改質器

34内を通過する原燃料ガスの流速は、第1反応部80内を通過するときの方が、第2反応部81内を通過するときよりも速くなる。

【0091】したがって、第1実施例の改質器34によれば、上流側における原燃料ガスの流速を速くすることによって、上流側における急激な温度上昇を抑え、改質器34内全体の温度分布状態を、改質反応に適した温度範囲である250～300℃の温度範囲内で均一化するという効果を奏する。図5は、ハニカム断面積が一定である従来知られる改質器と、本実施例の改質器34とについて、ガスの流れ方向に関する内部の温度分布状態を表わした説明図である。既述したように、酸化反応は水蒸気改質反応よりも反応速度が速いため、従来の改質器では、原燃料ガスの入り口部付近で酸化反応が活発に進行し、この入り口部付近の温度が400℃程度に上昇してしまう。これに対し、本実施例の改質器34では、上流側での原燃料ガスの流速が速いため、上流側で進行した酸化反応によって生じた熱が、速いガスの流れによって速やかに下流側に運ばれる。また、上流側での原燃料ガスの流速が速いため、上流側の狭い領域で酸化反応が終了してしまうことがなく、酸化反応が活発に進行する領域がより下流側に広がる。したがって、入り口部付近で温度が急激に上昇してしまうことがない。さらに、上流側に配設された第1反応部80は、厚いステンレス板を用いて形成したハニカムを備えているため、大きな熱容量を有しており、酸化反応で生じた熱は、このハニカムに伝えられてハニカムを昇温させる前に、ガスの流れによって下流側に伝えられ易くなっている。

【0092】このように、改質器34は、その入り口部付近で温度が急激に上昇してしまうことがないため、温度上昇に起因する既述した触媒劣化や副生成物の発生といった不都合を防止することができる。触媒の劣化が抑えられることによって改質器の耐久性を大きく向上させることが可能となり、従来の改質器が使用時間200時間程度の耐久性であったのに対し、本実施例の改質器34は、5000時間以上の使用が可能になった。

【0093】また、上記したように、酸化反応が進行する領域が下流側に広がると共に、上流側で進行した酸化反応で生じた熱が速やかに下流側に運ばれることによって、本実施例の改質器34では、その下流側で従来の改質器のように温度が低下しすぎるということがない。したがって、改質器の下流側においても、水蒸気改質反応の活性が高い状態に保たれ、下流側が備える触媒も充分に利用することができると共に、水蒸気改質反応の速度を向上させることができる。このように、下流側での水蒸気改質反応の活性が高められることによって、改質器をよりコンパクトにすることが可能となる。

【0094】上記した第1実施例では、改質器34が備えるハニカムはメタルハニカムとしたが、セラミックハニカムを用いることとしてもよい。メタルハニカムを用

いた構成を、第1実施例の変形例として以下に示す。この変形例における改質器も、第1実施例の改質器34と同様に、第1反応部80と第2反応部81とからなる。セラミックハニカムによって形成した第1反応部80および第2反応部81の断面の模式図を図6に示す。図6(A)は、セラミックハニカムで構成する第1反応部80の一例、図6(B)は、同じく第1反応部80の他の例、図6(C)は、セラミックハニカムで構成する第2反応部81を表わす。

【0095】図6(A)では、ハニカムを構成する各セルの断面積をそれぞれ小さく形成し、図6(B)では、ハニカムを構成するセルの総数を少なくすることによって、図6(C)のハニカムに比べてガスの流路断面の総面積を小さくしている。したがって、図6(A)と図6(B)のいずれの第1反応部80を用いる場合にも、図6(C)に表わした第2反応部81と組み合わせて改質器34を構成することによって、既述した第1実施例と同様の効果を得ることができる。

【0096】また、上記実施例では、改質器34の内部を第1反応部80と第2反応部81の2つに分割して、前半部と後半部とで内部を通過する原燃料ガスの流速が異なる構成としたが、改質器の内部を3つ以上に分割する構成としてもよい。この場合にも、上流側のガス流速が下流側よりも速くなる構成とすることによって、上記した実施例と同様の効果を得ることができる。

【0097】既述した実施例では、改質器の上流側に配設されたハニカムにおいて、単位断面積当たりのセルの数を少なくしたり、各セルの断面積を小さく形成することによって、上流側におけるガス流路断面の総面積を下流側に比べて小さくしている。上流側のガス流速が下流側よりも速くなる改質器の構成としては、既述した構成の他に、改質器全体の断面積を、上流側でより小さくなるように形成する構成を挙げることができる。このような改質器34Aの構成を図7に示す。改質器34Aは、総断面積の異なる3つのハニカムから構成されており、上流側ほど総断面積の小さなハニカムによって形成されている。このような構成とすれば、上流側のガス流速が下流側よりも速くなるため、既述した実施例と同様の効果を得ることができる。図5に、改質器34Aにおける内部の温度分布状態を示す。上記改質器34Aのように、改質器全体の総断面積を次第に大きくする構成とするならば、単位断面積当たりのセル数および各単セルの断面積は同じであってもよい。また、改質器を総断面積が異なる複数の部位によって構成する際には、3つ以外の複数の部位からなることとしてもよく、上流側ほど流路断面の総面積が小さくなる構成とするならば、既述した効果を得ることができる。

【0098】次に、改質器の上流部で進行する酸化反応によって生じた熱を積極的に下流側に伝達する他の構成として、水蒸気改質反応および酸化反応を促進する触媒

を、熱伝導性の比較的高い材料で形成される担体で保持する構成を、第2実施例として以下に説明する。図8は、第2実施例の改質器90の構成を模式的に表わす説明図である。第2実施例の改質器90は、図1の燃料電池装置20と同様の構成の燃料電池装置に備えられている。図8に示すように、改質器90は、ハニカムによって構成された単一の反応部92からなる。この反応部92を構成するハニカムの断面の一部を表わす断面模式図を図9(A)に、また、図9(A)に示したハニカムの表面の一部(図9(A)中に領域Bとして円で囲んだ範囲)をさらに拡大した様子を模式的に表わす図を図9(B)に示す。

【0099】本実施例の改質器90は、第1実施例の改質器34と同様に、メタルハニカムによって構成されている。なお、本実施例では、厚さが0.05mmのステンレス板94を用いてハニカムを形成した。このステンレス板94の表面には、水蒸気改質反応および酸化反応を促進する触媒を含有し、厚さが約0.05mmの触媒層96が形成されている。触媒層96では、Cu-Zn触媒を構成する銅分子と酸化亜鉛分子とが、熱伝導性の高いバインダ中に分散した状態で担持されている。

【0100】ここで、触媒層96の調製方法について説明する。まず、触媒原料として、周知の共沈法によりCuO・ZnO粉末を作製し、これにバインダとしてアルミナゾル5%と、さらに、酸化アルミニウムに比べて熱伝導性の高い物質を添加する。ここで用いる熱伝導性の高い物質としては、窒化物である窒化アルミニウム(AlN)や窒化チタン(TiN)、あるいは炭化物である炭化シリコン(SiC)や炭化ホウ素(B₄C)、あるいはグラファイトなどを挙げることができ、添加量としては5~30%が好ましい。例えば、上記した熱伝導性の高い物質の中で、AlNは、0.07cal/cm/s/°Cの熱伝導率を示し、SiCは0.1cal/cm/s/°C、グラファイトは0.30.1cal/cm/s/°Cの熱伝導率を示し、いずれも、従来用いられてきた酸化アルミニウム(0.02cal/cm/s/°C)に比べて高い熱伝導率を示す。

【0101】これらを水で希釈してボールミルで粉碎混合し、ステンレス板94上に塗布し、さらに加熱処理および還元処理を行なう。このような処理によって、上記触媒原料は、銅分子と酸化亜鉛分子とからなるCu-Zn触媒となり、これらのCu-Zn触媒は、熱伝導性の高い物質を含有するバインダ中に分散して担持された状態で、触媒層96を形成する。

【0102】以上のように構成した改質器90を燃料電池装置20に適用し、改質器90に対して原燃料ガスを供給すると、既述したように、酸素が供給される上流側では酸化反応が活発に行なわれて多くの熱が生じる。このように酸化反応によって生じた熱は、上流側で進行する水蒸気改質反応で利用される他に、既述した熱伝導性

の高い物質を含有するバインダ中を速やかに伝えられる。このようにバインダ中を伝えられる熱のうちの所定量は、熱伝導性の高いステンレスによって形成されたハニカム基材にさらに伝えられる。ステンレスからなるハニカム基材に伝えられた熱は、このハニカム基材を介して下流側に伝えられる。また、ハニカム基材に伝えられない残りの熱は、そのままバインダ中を下流側に伝えられる。このように改質器90の下流側に伝えられた熱は、下流側で進行する水蒸気改質反応で利用される。

【0103】したがって、本実施例の改質器90によれば、熱伝導性の高いバインダ中に触媒が担持されているため、上流側で酸化反応のために生じた熱が速やかに下流側に伝えられ、上流側における急激な温度上昇を抑えることができる。図10は、上記熱伝導性の高い物質を含まないバインダを用いた従来知られる改質器と、本実施例の改質器90とについて、ガスの流れ方向に関する内部の温度分布状態を表わした説明図である。本実施例の改質器90は、従来の改質器とは異なり、上流側で進行する酸化反応で生じた熱が速やかに下流側に伝えられるため、上流側が急激に昇温されることなく、改質器の内部温度を250～300℃の温度範囲で均一化することができる。このように、改質器90は、その入り口部付近で温度が急激に上昇してしまうことがないため、温度上昇に起因する既述した触媒劣化や副生成物の発生といった不都合を防止することができる。触媒の劣化が抑えられることによって改質器の耐久性を大きく向上させることが可能となり、従来の改質器が使用時間200時間程度の耐久性であったのに対し、本実施例の改質器90は、5000時間以上の使用が可能になった。

【0104】また、上記したように、上流側で進行した酸化反応によって生じた熱が速やかに下流側に伝えられるため、本実施例の改質器90では、その下流領域で従来の改質器のように温度が低下しすぎることがない。したがって、改質器の下流側においても、水蒸気改質反応の活性が高い状態に保たれ、下流側が備える触媒も充分に利用することができると共に、水蒸気改質反応の速度を向上させることができる。そのため、改質器をよりコンパクトにすることが可能となる。

【0105】上記第2実施例では、熱伝導性に優れたステンレス板を基材とするハニカム上に、熱伝導性の高い物質を含有するバインダを用いた触媒層96を形成したため、上流から下流への熱伝導は、触媒層96自身によるものと、ステンレス板94を介するものの両方が行なわれ、高い効率で伝熱を行なうことができ、特に優れた効果を得ることができた。ここで、触媒層96を、セラミックハニカム上に形成したり、触媒を熱伝導性の高いバインダとともにペレット状に成形し、改質器内に充填する構成としても、上流側から下流側への熱伝導性が向上することによる所定の効果を得ることができる。

【0106】次に、第3実施例として、改質器内の上流

側が担持する触媒量を下流側に比べて少なくすることによって、上流側において酸化反応の活性を抑えた構成を以下に示す。図11は、第3実施例の改質器100の構成を模式的に表わす説明図である。この改質器100は、図1の燃料電池装置20と同様の構成の燃料電池装置に備えられている。図11に示すように、改質器100は、第1反応部101と第2反応部102とを備えている。これら第1反応部101および第2反応部102は、同様の形状のハニカムによって構成されており、このハニカム表面に、既述した実施例と同様のCu-Zn触媒が担持されているが、ハニカム上に担持された触媒の量が、第1反応部101よりも第2反応部102の方が多くなっている。すなわち、第1反応部101は、50g/l（ハニカムの単位体積当たりの触媒量）の割合でCu-Zn触媒を担持しているのに対し、第2反応部102は、180g/lの割合でCu-Zn触媒を担持している。

【0107】以上のように構成した改質器100によれば、上流側の第1反応部101が担持する触媒量が少ないため、原燃料ガスおよび空気の導入側での酸化反応の進行が抑えられる。したがって、改質器の上流側で急激に酸化反応が進行してしまうことがなく、酸化反応が行なわれる領域がより下流側に広がる。したがって、上流側における急激な温度上昇を抑えることができる。

【0108】図12は、上流側も下流側と同量の触媒を担持するハニカムを備えた従来知られる改質器と、本実施例の改質器100とについて、ガスの流れ方向に関する内部の温度分布状態を表わした説明図である。本実施例の改質器100は、従来の改質器とは異なり、上流側では酸化反応の進行が抑えられるため、上流側が急激に昇温されることなく、改質器の内部温度を250～300℃の温度範囲で均一化することができる。このように、改質器100は、その入り口部付近で温度が急激に上昇してしまうことがないため、温度上昇に起因する既述した触媒劣化や副生成物の発生といった不都合を防止することができる。触媒の劣化が抑えられることによって改質器の耐久性を大きく向上させることが可能となり、従来の改質器が使用時間200時間程度の耐久性であったのに対し、本実施例の改質器100は、5000時間以上の使用が可能になった。

【0109】また、上記したように、発熱を伴う酸化反応が進行する領域がより下流側に広がるため、本実施例の改質器100では、その下流領域で従来の改質器のように温度が低下しすぎることがない。したがって、改質器の下流側においても、水蒸気改質反応の活性が高い状態に保たれ、下流側が備える触媒も充分に利用することができると共に、水蒸気改質反応の速度を向上させることができる。そのため、改質器をよりコンパクトにすることが可能となる。

【0110】なお、上記第3実施例では、改質器100

において、担持する触媒量を2段階に変化させることにしたが、3段階以上に変化させることとしてもよく、上流側の触媒担持量を減らすことによって、上記した所定の効果を得ることができる。ここで、上流側ほど触媒の担持量を減らす構成とし、触媒の担持量を変化させる段階の数を調節することによって、改質器内部の温度をより均一化させることが可能となり、既述した効果を高めることができる。

【0111】また、上記第3実施例では、水蒸気改質反応と酸化反応とは、同一のCu-Zn触媒によって促進することとしたが、水蒸気改質反応と酸化反応とを異なる触媒によって促進することとしてもよい。このような場合には、改質器の上流側と下流側とで触媒の総担持量を変える代わりに、酸化反応を促進する触媒の担持量だけを、上流側で少なくすればよい。

【0112】次に、第4実施例として、改質器に供給するガス中の酸素濃度を下げることによって、上流側での酸化反応の活性を抑えたと共に、供給するガスの流速を速めて上流側における酸化反応で生じた熱を下流側に伝える構成を示す。図13は、第4実施例の改質器110の構成を模式的に表わす説明図である。この改質器110は、図1の燃料電池装置20とほぼ同様の構成の燃料電池装置に備えられており、共通する部材には同じ部材番号を付して以下の説明を行なう。

【0113】ここで、既述した実施例では、ブロワ38から改質器に空気を供給する空気供給路39は一旦第2燃料供給路64と合流しており、原燃料ガスは、空気を混合された上で改質器に供給されていたが、第4実施例の改質器110を備える燃料電池装置では、上記空気供給路39は、改質器110に直接接続している。また、本実施例の改質器110を備える燃料電池装置では、燃料電池40から酸化排ガス路69に排出される酸化排ガスもまた、ブロワ38から取り込まれる空気と共に、改質器110に供給可能となっている。通常の空気には約20%の酸素が含有されているが、燃料電池から排出される酸化排ガスは、燃料電池における電気化学反応で所定量の酸素が消費されているため、含有する酸素量は空気より少ない。酸化排ガス中の酸素濃度は、燃料電池に供給される酸化ガスにおける空気過剰率（実際に供給した空気中の酸素量と理論上必要とされる酸素量との割合）などによって変わるが、本実施例の燃料電池装置では、酸化排ガス中の酸素濃度は、約10%となる。したがって、改質器110に対して、空気と酸化排ガスとを混合して供給可能とすることによって、改質器110に供給する空気中の酸素濃度を、約10%～約20%の範囲内で調節することが可能となる。

【0114】図13に基づいて、改質器110の構成を詳しく説明する。改質器110は、表面にCu-Zn触媒が担持されたハニカムによって構成される単一の反応部111を備える。また、上記空気供給路39および酸

化排ガス路69は、合流して第2空気供給路115となり、この第2空気供給路115は、改質器110において、第2燃料供給路64から原燃料ガスが供給される上流側に対して、空気と酸化排ガスとの混合気体（以下、混合空気と呼ぶ）を供給する。空気供給路39には、第2空気供給路115への合流部の付近にマスフロコントローラ112が設けられており、第2空気供給路115側に供給する空気量を調節可能になっている。また、酸化排ガス路69には、同じく第2空気供給路115への合流部の付近にマスフロコントローラ113が設けられており、第2空気供給路115側に供給する酸化排ガスを調節可能になっている。これらマスフロコントローラ112、113は、既述した制御部50に接続されており、制御部50によって、空気供給路39から供給される空気と、酸化排ガス路69から供給される酸化排ガスとが混合される際の混合量が制御される。さらに、第2空気供給路115には酸素濃度センサ114が設けられている。この酸素濃度センサ114もまた制御部50に接続されており、混合空気中の酸素濃度に関する情報が、制御部50に入力可能となっている。また、反応部111内部において、その上流側の端部から所定の位置には、温度センサ117が設けられている。この温度センサ117も制御部50に接続されており、反応部111内の温度に関する情報が、制御部50に入力可能となっている。

【0115】本実施例の改質器110は、所定量の酸素を含有する混合空気を改質器110に供給する際に、この混合空気中の酸素濃度を低下させると共に、反応部111内を通過するガス全体の流速を増加させ、改質器110の上流部で温度が急激に上昇してしまうのを抑える。すなわち、改質器110に供給する混合空気中の酸素濃度を低下させることによって、反応部111内を通過するガス中の酸素濃度も低下し、それによって上流側での酸化反応の活性が抑えられ、急激な温度上昇を防ぐことができる。また、所定量の酸素を含有する混合空気中の酸素濃度を低下させることによって、反応部111に供給される混合空気量が増大し、反応部111内を通過するガスの流速が速まる。それによって、上流側で進行する酸化反応で酸素が使い果たされる前に、より下流側に酸素が運ばれ、酸化反応が進行する領域をより下流側に広げることができる。さらに、反応部111内を通過するガスの流速を速めることによって、上流側で進行する酸化反応で生じた熱は速やかに下流側に伝えられ、反応部の上流側が昇温しすぎるのを防ぐことができる。

【0116】図14は、本実施例の改質器110を備える燃料電池装置で実行される空気混合量制御処理ルーチンを表わすフローチャートである。本ルーチンは、改質器110を備える燃料電池装置において、図示しない所定のスタートスイッチを操作することによってこの燃料電池装置の始動が指示された後に、改質器110内部が

充分に昇温して定常状態に達したと判断されると、所定の時間毎に実行される。

【0117】本ルーチンが実行されると、CPU 54 は、まず、メタノール流路 60 に設けられた第 2 ポンプ 71 の駆動量を基に、改質器 110 に供給される原燃料ガス中のメタノール量の読み込みを行なう（ステップ S 200）。次に、このメタノール量に基づいて、改質器 110 に供給すべき酸素量を求め、必要量の酸素を供給可能となるように、マスフロコントローラ 112、113 を駆動する（ステップ S 210）。すなわち、改質器に供給されるメタノール量が決定されれば、水蒸気改質反応で要する熱量と酸化反応で生じる熱量とを釣り合わせるために必要な酸素量を決定することができるため、この決定した酸素量を含有する空気が改質器 110 に供給されるように、マスフロコントローラ 112、113 を駆動する。ここで、供給すべき酸素量が決定されたときに、供給すべき酸素量を供給するために各マスフロコントローラを駆動する駆動量は、基準駆動量として、それぞれの供給酸素量に対して予め決定されて制御部 50 内に記憶されている。

【0118】マスフロコントローラ 112、113 を駆動して、必要量の酸素を含有する混合空気を改質器 110 に対して供給し始めると、次に、温度センサ 117 から、反応部 111 における上流側の内部温度 T1 を読み込む（ステップ S 220）。次に、この内部温度 T1 を、所定の基準温度 Ta と比較する（ステップ S 230）。ここで、所定の基準温度 Ta とは、上流側の内部温度 T1 の上限として予め設定して制御部 50 に記憶させておいた値であり、本実施例では 300℃ とした。

【0119】ステップ S 230 において、上流側の内部温度 T1 が上記所定の基準温度 Ta よりも小さい場合には、反応部 111 の上流側の内部温度 T1 は十分に低い温度であると判断されて、そのまま本ルーチンは終了される。上流側の内部温度 T1 が上記所定の基準温度 Ta 以上である場合には、マスフロコントローラ 112 の駆動量を減らすと共に、マスフロコントローラ 113 の駆動量を増やす。すなわち、改質器 110 に供給する混合空気において、単位時間当たりに供給する酸素量を変えることなく、酸化排ガスの割合を増加させる（ステップ S 240）。このステップ S 240 における酸化排ガスの割合の変化量、すなわち、改質器 110 に供給する混合空気中の酸素濃度の変化量は、本実施例では、予め最小単位の変化量を定めておき、この最小単位毎に酸素濃度を低下させることとした。あるいは、内部温度 T1 が基準温度 Ta を越える量に応じて調節することとしてもよい。酸化排ガスの割合を増加させることによって、改質器 110 に供給されるガス全体での酸素濃度が低下するため、上流側で進行する酸化反応が抑えられる。また、単位時間当たりに供給する酸素量を変えることなく酸化排ガスの割合を増加させることで、改質器 110 に

供給される混合空気量が増加し、改質器 110 内を通過するガスの流速が速まり、上流側で進行する酸化反応で生じた熱がより速やかに下流側に運ばれるようになる。したがって、ステップ S 240 を実行することによって、反応部 111 の上流側の内部温度 T1 を下げることができる。

【0120】ステップ S 240 において酸化排ガスの割合を変えると、次に、再びステップ S 220 に戻って、内部温度 T1 の読み込みおよびこの内部温度 T1 と所定の基準温度 Ta との比較の動作を繰り返す。ステップ S 230 において内部温度 T1 が所定の基準温度 Ta よりも低くなると、改質器 110 に供給される混合空気中の酸化排ガスの割合が適当となり、反応部 111 の上流側の内部温度 T1 は十分に低くなったと判断されて、本ルーチンを終了する。

【0121】なお、本実施例の改質器 110 を備える燃料電池装置は、既述したように酸素濃度センサ 114 を第 2 空気供給路 115 に備えており、その検出結果に基づいて、改質器 110 に供給する混合空気中の酸素濃度を補正する。すなわち、上記空気混合量制御処理ルーチンにおけるステップ S 210 あるいはステップ S 240 において、マスフロコントローラを駆動したときには、改質器 110 に供給する混合空気中の酸素濃度を酸素濃度センサ 114 によって検出し、その結果に基づいてマスフロコントローラの駆動量を補正している。

【0122】以上のように構成された第 4 実施例の改質器 110 を備える燃料電池装置によれば、改質器 110 に供給される混合空気中の酸素濃度を制御することができるため、上記混合空気中の酸素濃度を低くすることによって、原燃料ガスおよび混合空気の導入側において酸化反応が進行するのを抑えることができる。したがって、上流側における急激な温度上昇を抑えることができる。さらに、単位時間当たり所定量の酸素を改質器 110 に供給しながら混合空気中の酸素濃度を下げることによって、混合空気の流量が増大し、反応部 111 内部を通過するガスの流速が速まる。したがって、上流側で進行する酸化反応で生じた熱は速やかに下流側に伝えられて、上流側で温度が上昇しすぎるのを抑えることができる。

【0123】また、上記したように上流側において酸化反応が抑えられることによって、酸化反応が進行する領域がより下流側に広がるため、本実施例の改質器 110 では、その下流領域で従来の改質器のように温度が低下しすぎることがない。さらに、反応部 111 内部を通過するガスの流速が速まることによって、上流側で生じた熱が下流側に伝えられ易くなるため、下流領域での温度低下がさらに抑えられる。したがって、改質器 110 では、その下流側においても水蒸気改質反応の活性が高い状態に保たれ、下流側が備える触媒も充分に利用することができると共に、水蒸気改質反応の速度を向上させる

ことができる。そのため、改質器をよりコンパクトにすることが可能となる。

【0124】上記第4実施例では、メタノール流路60に設けられた第2ポンプ71の駆動量を基に、改質器110に供給される原燃料ガス中のメタノール量を読み込み、また、温度センサ117の検出結果を基に、上流側において酸化反応が過剰に進行していないかどうかを判断している。改質器110に供給されるメタノール量や、改質器110における酸化反応と水蒸気改質反応との進行状態に関するこのような判断は、上記以外の測定量によって、あるいは、上記以外の測定量をさらに利用して行なうこととしてもよい。例えば、改質器110内における水蒸気改質反応と酸化反応との進行状態を判断するために、第3燃料供給路65に、第3燃料供給路65を通過するガス中の成分を分析可能な機器を配設し、改質器110から排出される燃料ガス中のメタノール、水素、二酸化炭素、酸素などの量を測定し、この測定結果をさらに利用して、改質器110内における水蒸気改質反応および酸化反応の進行状態を判断することとしてもよい。

【0125】上記第4実施例では、混合空気は、改質器110の上流側だけから供給する構成としたが、複数箇所から混合空気を供給する構成も好ましい。このような構成を、第4実施例の変形例として以下に示す。図15は、第4実施例の変形例である改質器110Aの構成を模式的に表わす説明図である。改質器110Aは、2つの反応部111A、111Bを備えており、それぞれの反応部に対して混合酸素が供給される。ここで、改質器110Aに供給される原燃料ガスは、反応部111A、111Bの順で通過する。また、改質器110Aに対して空気および酸化排ガスを供給する空気供給路39および酸化排ガス路69は、それぞれ、空気分岐路39A、39B、酸化排ガス分岐路69A、69Bに分岐する。空気分岐路39Aと酸化排ガス分岐路69Aとは合流して第2空気供給路115Aとなり、上流側に配設された反応部111Aに対して混合空気を供給する。空気分岐路39Bと酸化排ガス分岐路69Bとは合流して第2空気供給路115Bとなり、下流側に配設された反応部111Bに対して混合空気を供給する。それぞれの反応部に供給される混合空気中の酸素量および酸素濃度は、第4実施例と同様に、改質器110Aに供給されるメタノール量や、各反応部の上流側の温度などに基づいて、マスフローコントローラ112A、112B、113A、113Bの駆動量を調節することによって制御される。

【0126】以上のように構成された改質器110Aによれば、混合空気を分割して供給しているため、一度に供給する混合ガス中の酸素量を減らすことができ、局所的に温度が上昇しすぎてしまうのを防ぐ効果をさらに高めることができる。さらに、改質器内部を複数の反応部に分割し、各反応部ごとに混合空気を供給することによ

って、改質器内部の温度分布をより精度よく制御することが可能となり、より容易に改質器の内部全体を望ましい温度範囲に保つことができる。

【0127】図16は、酸化反応で要する酸素源として、改質器に対しては通常の空気だけを供給する従来知られる改質器と、上述した改質器110Aについて、ガスの流れ方向に関する内部の温度分布状態を表わした説明図である。改質器110Aは、従来の改質器とは異なり、上流側における酸化反応の進行が抑えられるため、上流側が急激に昇温されることなく、改質器の内部温度を250〜300℃の温度範囲で均一化することができる。以上説明したように、本実施例の改質器110および110Aは、その入り口部付近で温度が急激に上昇してしまうことがないため、温度上昇に起因する既述した触媒劣化や副生成物の発生といった不都合を防止することができる。したがって、既述した実施例と同様に、改質器の耐久性を大きく向上させることが可能となる。

【0128】また、既述した実施例の改質器110および110Aは、ハニカムによって構成された反応部を備えることとしたが、改質器の内部に、触媒を担持したペレットを充填する構成としてもよい。この場合にも、酸化反応に要する酸素源として、改質器に供給する混合空気中の酸素濃度を制御可能とすることによる同様の効果を得ることができる。

【0129】上記第3および第4実施例では、改質器の上流側で進行する酸化反応の活性を抑えることによって、上流側で急激な温度上昇が起こらないようにしたが、触媒部内部において、酸化反応が活発に進行する領域と、酸化反応の進行が不活発な領域とを変更可能とすることによって、熱が生じる領域を変更し、局所的に温度が上昇しすぎるのを防ぐことも可能である。以下に、このような構成として、原燃料ガスおよび酸素が導入される入り口部と、水素リッチな燃料ガスが排出される出口部とが切り替え可能な改質器を、第5実施例として説明する。

【0130】図17は、第5実施例の改質器120の構成を模式的に表わす説明図である。この改質器120は、図1の燃料電池装置20と同様の構成の燃料電池装置に備えられている。図17に示すように、改質器120は、表面にCu-Zn触媒を担持するハニカムによって構成された単一の反応部121を備える。この反応部121は、その両端部の内部温度を測定する温度センサ122および温度センサ123を備えている。これらの温度センサは、既述した制御部50に接続されており、反応部121の両端部における内部温度に関する情報は、制御部50に入力される。

【0131】また、本実施例では、第2燃料供給路64は、第1供給分岐路124と第2供給分岐路125とに分岐しており、それぞれの分岐路は、改質器120のそれぞれの端部に接続する。ここで、改質器120の一端

は、上記第1供給分岐路124と接続するほかに、第1排出分岐路126とも接続している。また、改質器120の他端は、上記第2供給分岐路125と接続するほかに、第2排出分岐路127と接続している。これらの第1排出分岐路126と第2排出分岐路127とは、合流して第3燃料供給路65となり、CO低減部36に接続する。さらに、上記第1供給分岐路124、第2供給分岐路125、第1排出分岐路126、第2排出分岐路127には、それぞれ、電磁弁128、129、128A、129Aが設けられている。これらの電磁弁128、129、128A、129Aは、制御部50に接続されており、制御部50によってその開閉状態が制御される。

【0132】このような改質器120では、通常は、上記電磁弁の開閉状態は、電磁弁128と128Aが開状態、電磁弁129と129Aが閉状態となる第1の状態と、電磁弁129と129Aが開状態、電磁弁128と128Aが閉状態となる第2の状態のいずれかとなる。電磁弁の開閉状態が上記第1の状態となるときには、第2燃料供給路64から供給される原燃料ガスは、反応部121内において、図13中向かって左側から右側に向かって通過する。また、電磁弁の開閉状態が上記第2の状態となるときには、原燃料ガスは、反応部121内において、図13中向かって右側から左側に向かって通過する。

【0133】図18は、改質器120において上記したようなガスの入り口部の切り替えが行なわれる際に、燃料電池装置20で実行されるガス入り口切り替え処理ルーチンを表すフローチャートである。本ルーチンは、燃料電池装置20において、図示しない所定のスタートスイッチを操作することによって燃料電池装置20の始動が指示されると、所定の時間毎に実行される。

【0134】本ルーチンが実行されると、まず、CPU54は、既述した各電磁弁の開閉状態から、電磁弁の開閉状態が第1の状態であるか否かを判断する(ステップS300)。第1の状態であると判断された場合には、ガスが供給される上流側の端部における内部温度T1を、温度センサ122から読み込む(ステップS310)。次に、この内部温度T1を、予め設定した所定の基準温度T0と比較する(ステップS320)。ここで、所定の基準温度T0とは、反応部121の内部温度が非所望の状態にまで昇温しつつあることを示す基準となる温度として予め制御部50内に記憶させた値であって、本実施例では、300℃に設定した。ステップS320において内部温度T1が基準温度T0に達していないときには、ステップS310に戻り、内部温度T1が基準温度T0に達するまで、上記した内部温度の読み込みと比較の動作を繰り返す。

【0135】ステップS320において内部温度T1が基準温度T0以上であると判断されると、次に、すべて

の電磁弁を閉状態にすると共に、制御部50に備えられた図示しない所定のタイマにより経過時間tの測定を開始する(ステップS330)。ステップS330においてすべての弁を閉状態にすることによって、改質器120におけるガスの出入りは停止され、反応部121内では、残留する原燃料ガスをを用いた水蒸気改質反応および酸化反応がそのまま続行される。次に、経過時間tを、予め設定した所定の基準時間t0と比較する(ステップS340)。ここで、所定の基準時間t0とは、上記したようにすべての弁を閉状態としたときに、改質器120内部に残留する原燃料ガスをを用いた水蒸気改質反応および酸化反応が完了するのに要する時間として、予め制御部50内に記憶させた値であって、本実施例では1secに設定した。ステップS340において経過時間tが基準時間t0に達していないときには、基準時間t0が経過するまでステップS340の動作を繰り返す。ステップS340において、経過時間tが基準時間t0に達したときには、所定の電磁弁に駆動信号を出力して電磁弁の開閉状態を第2の状態にして(ステップS350)、本ルーチンを終了する。

【0136】また、ステップS300において、第1の状態でないと判断されたときには、改質器120は第2の状態であると判断され、ガスが供給される上流側の端部における内部温度T2を、温度センサ123から読み込む(ステップS360)。その後は、ステップS370～ステップS390まで、既述したステップS320～ステップS340までと同様の処理を行なう。すなわち、酸化反応の進行と共に内部温度T2が所定の基準値T0(本実施例では300℃)に達すると、所定の時間(本実施例では1sec)すべての弁を閉状態とし、その後電磁弁の開閉状態を第1の状態にして(ステップS400)、本ルーチンを終了する。

【0137】なお、上記したガス入り口切り替え処理ルーチンは、既述したように、図示しない所定のスタートスイッチを操作することによって燃料電池装置20の始動が指示されると、所定時間毎に実行されることとしたが、燃料電池装置20の始動が指示された最初の状態としては、各電磁弁の開閉状態は、上記した第1の状態または第2の状態となるようにしておけばよい。例えば、前回に燃料電池装置20を停止したときと同じ状態で、次回に燃料電池装置20を始動することとしてもよいし、燃料電池装置20の始動時には各電磁弁の開閉状態が上記第1の状態あるいは第2の状態になるように設定しておいてもよい。

【0138】以上のように構成された第5実施例の改質器120を備える燃料電池装置によれば、改質器120に供給する混合空気中の供給箇所を上流側と下流側とで切り替え、反応部121内のガスの流れの方向を逆転させることができるため、酸化反応で生じる熱によって、改質器の一方の端部だけが昇温しすぎることがない。し

たがって、上流側における急激な温度上昇を抑えることができる。ここで、ガスの流れの方向の切り替えは、反応部121の端部の温度に基づいて行なうため、反応部121の端部の温度が上昇しすぎてしまうのをより確実に防ぐことが可能となる。

【0139】また、上記したようにガスの流れの方向を切り替えることによって、反応部121の両端が上流側となり得るため、従来の改質器のように特定の下流側で温度が低下しすぎることがない。したがって、改質器120では、その両側で水蒸気改質反応の活性が高い状態に保たれ、反応部121全体が備える触媒を充分に利用することができると共に、水蒸気改質反応の速度を向上させることができる。そのため、改質器をよりコンパクトにすることが可能となる。

【0140】図19は、内部のガスの流れの方向が一定である従来知られる改質器と、上述した改質器120とについて、一端側から他端側への内部の温度分布状態を表わした説明図である。改質器120は、従来の改質器とは異なり、特定の端部側において酸化反応が進行しすぎるのが抑えられ、また、両端部側が上流側となり得るため、改質器の内部温度を250～300℃の温度範囲で均一化することができる。以上説明したように、本実施例の改質器120は、その入り口部付近で温度が急激に上昇してしまうことがないため、温度上昇に起因する既述した触媒劣化や副生成物の発生といった不都合を防止することができる。したがって、既述した実施例と同様に、改質器の耐久性を大きく向上させることが可能となる。

【0141】なお、本実施例の改質器120は、ハニカムによって構成された反応部を備えることとしたが、改質器の内部に、触媒を担持したペレットを充填する構成としてもよい。この場合にも、改質器内を通過するガスの流れの方向を切り替えることによる同様の効果を得ることができる。

【0142】また、本実施例の改質器120は、反応部121の端部の温度に基づいて、ガスの流れの方向を切り替えることとしたが、切り替えのタイミングは、他の要因に基づくこととしても良い。反応部121の端部温度に基づく場合には、改質器120に供給される原燃料ガスの量が変動して、改質器120内部で進行する水蒸気改質反応と酸化反応との量が変動する場合にも、内部温度を所定の範囲内に保つ上で高い効果が得られるという利点があるが、例えば、改質器に供給される原燃料ガス量の変動が小さい場合には、所定の時間毎にガスの流れの方向を切り替えることとしてもよい。

【0143】次に、第6実施例として、改質器内部に封入した触媒粒子を攪拌することによって、改質器内の特定の上流側だけが昇温しすぎてしまうのを防ぐ構成を示す。図20は、第6実施例の改質器130およびこの改質器130と接続される部材の構成を模式的に表わす説

明図である。本実施例の改質器130は、図1の燃料電池装置20と同様の構成の燃料電池装置に備えられているため、以下の説明では、共通する部材については同じ部材番号を付して詳しい説明を省略する。

【0144】改質器130は、既述したCu-Zn触媒からなる粒子を内部に封入されている。この触媒は、周知の共沈法により作製したCu-Zn触媒を、約500μmの粒径となるように造粒したものである。あるいは、Cu-Zn触媒を、所定の溶媒に分散させた上でスプレードライヤ装置に供給し、噴霧することによって上記した粒径の微粒子を作製することとしてもよい。また、触媒粒子の粒径は、上述するようにこの触媒粒子を封入する改質器内にガスを噴射する際に、このガスによって充分に攪拌されうる大きさであればよく、例えば、100μm～数mmの粒径とすることが好ましい。また、触媒粒子の形状はいかなるものであってもよいが、後述する攪拌の効率を考えると、球状に近い方が好ましい。

【0145】改質器130は、既述した実施例と同様に、メタノールおよび水蒸気からなる原燃料ガスが蒸発器32から供給されると共に、ブロワ38から空気が供給されるが、本実施例では、これらの原燃料ガスおよび空気は、調圧弁132および噴射ノズル134を介して改質器130内に供給される。蒸発器32では、メタノールおよび水が気化・昇温されるため、蒸発器32からは所定の温度と圧力を有する状態で原燃料ガスが排出される。この原燃料ガスは、空気供給路39から供給される空気と混合された後、調圧弁132および噴射ノズル134を介して改質器130内に噴射される。改質器130内には、上記したように触媒粒子が封入されているため、空気を含有する原燃料ガスを噴射することによって触媒粒子は、図20中矢印で示すように改質器130内で流動し、攪拌される。ここで、本実施例の改質器130では、空気を含有する原燃料の噴射は7カ所から行なうこととしたが、改質器内で触媒粒子を充分に攪拌可能であれば噴射箇所数は異なる構成としてもよい。また、改質器130内部の容積は、所定量の触媒粒子が、所定の流量、所定の圧力で供給されるガス（酸素を含む原燃料ガス）によって、充分に攪拌され得る大きさであればよい。

【0146】改質器130において、噴射ノズルが接続する端部と反対側の端部には、発泡ニッケルによって形成されたフィルタ136が設けられている。このフィルタ136は、十分に目の細かいメッシュ状に形成されているため、改質器130内に封入された触媒粒子が外部に漏れるのは妨げるが、改質器130内で生成された燃料ガスがCO低減部36側に供給されるのは妨げない。フィルタ136を通過した燃料ガスは、CO低減部36に供給されて一酸化炭素濃度が低減された後、燃料電池40に供給される。

【0147】以上のように構成された改質器130を備える燃料電池装置によれば、改質器130内に封入された触媒粒子は、空気を含む原燃料ガスによって常に攪拌されるため、高濃度の酸素を含む原燃料ガスが供給される位置に存在する触媒粒子が常に入れ替わり、酸化反応で生じる熱によって触媒の特定の領域だけが昇温しすぎてしまうことがない。ここで、触媒粒子を攪拌するために改質器内に噴射するガスは、改質器内で進行する水蒸気改質反応および酸化反応に供するためのガス（空気を含む原燃料ガス）であるため、改質器130に原燃料を供給する動作と、触媒粒子を攪拌する動作とを同時に行なうことができる。また、改質器内にガスを噴射することによって、改質器内の反応や燃料電池における電気化学反応が影響を受けることがない。

【0148】また、改質器130内における触媒粒子の攪拌によって、酸化反応で生じた熱も改質器130内に分散されるため、従来の改質器のように特定の下流側で温度が低下しすぎることがない。したがって、改質器130では、触媒粒子全体において水蒸気改質反応の活性が高い状態に保たれ、水蒸気改質反応の速度を向上させることができる。

【0149】図21は、内部のガスの流れの方向が一定である従来知られる改質器と、上述した改質器130とについて、一端側から他端側への内部の温度分布状態を表わした説明図である。ここで、改質器130に供給するガスは、温度250℃、流量670l/minの原燃料ガスと、流量140l/minの空気とを混合し、5気圧にて噴射ノズル134から改質器130内に噴射した。改質器130は、従来の改質器とは異なり、特定の端部側において酸化反応が進行しすぎることがなく、また、内部の触媒粒子が均等な状態で反応に関わるため、改質器の内部温度を250～300℃の温度範囲で均一化することができる。以上説明したように、本実施例の改質器130は、その入り口部付近で温度が急激に上昇してしまうことがないため、温度上昇に起因する既述した触媒劣化や副生成物の発生といった不都合を防止することができる。したがって、既述した実施例と同様に、改質器の耐久性を大きく向上させることが可能となる。

【0150】なお、上記第6実施例では、攪拌のために改質器130内に噴射するガスとして、空気を含む原燃料ガスをを用いたが、メタノールガス、水蒸気、空気のうち少なくともいずれか一つからなるガスをを用いることとしてもよい。この場合には、触媒の攪拌のために改質器内に噴射するのに用いなかった残りの成分は、改質器の所定の位置（上記噴射位置に近い上流側であることが望ましい）から、改質器内に対して、触媒粒子が封入された状態を維持しつつ供給することとすればよい。

【0151】また、上記第6実施例では、改質器130内に高圧のガスを噴射することによって、改質器130内に封入した触媒粒子を攪拌しているが、ガスの噴射以

外的手段によって触媒粒子を攪拌することとしてもよい。例えば、改質器内に、内部の触媒粒子を攪拌可能な機械的な手段を設けることとしてもよい。

【0152】次に、第7実施例として、触媒部において、酸化反応に供する空気が供給される箇所を経時的に変化させる構成を示す。図22は、第7実施例の改質器140の構成を模式的に示す説明図である。この改質器140は、図1の燃料電池装置20と同様の構成の燃料電池装置に備えられている。図22に示すように、改質器140は、表面にCu-Zn触媒を担持するハニカムによって構成された単一の反応部141を備え、略円筒形状に形成されている。また、改質器140は、図示しない所定のモータによって回転可能となっている。ここで、改質器140は、既述した実施例と同様に、第2燃料供給路64から原燃料ガスが供給されると共に、生成した燃料ガスを第3燃料供給路65へ排出するが、これら第2燃料供給路64および第3燃料供給路65は、改質器140の略円形をした断面の略中心部に接続している。上記したモータを駆動することによって、改質器140は、上記断面の中心部を中心として、毎秒1回転の速度で回転する。

【0153】また、改質器140には、第2燃料供給路64から原燃料ガスが供給されると共に、空気供給路39から空気が供給されるが、本実施例では、この空気供給路39における改質器140との接続側の端部は、第2燃料供給路64内に形成されている。第2燃料供給路64内に形成された空気供給路39の端部は、改質器140において反応部141の上流側に設けられた空間内で湾曲し、その後吹き出し口142として開口している。この吹き出し口142は、反応部141の上流側の端部に対面して開口しており、その開口する位置は、本実施例では、反応部141の端部断面の中心点と、同じく端部断面の円周部との中間付近とした。空気供給路39から供給される空気を、この吹き出し口142から吹き出すことによって、反応部141を構成するハニカムの各セルのうち、吹き出し口142の全面にあるセルを中心として、約半数のセルに対して空気を供給することができる。

【0154】したがって、本実施例の改質器140を用いると、吹き出し口142から空気の供給を受けるセルにおいては、水蒸気改質反応と酸化反応との両方が進行し、空気の供給を受けないセルにおいては、水蒸気改質反応だけが進行する。このとき、改質器140は、既述したように回転し、吹き出し口142の位置は改質器140の回転の状態に関わらず変化しないため、空気の供給を受けるセルは経時的に変化する。

【0155】以上のように構成された第7実施例の改質器140によれば、空気の供給を受けて酸化反応を進行するセルが経時的に変化するため、特定のセルの上流部において温度が上昇しすぎてしまうことがない。空気の

供給を受けて酸化反応が進行し、上流側が昇温しかかったセルでは、直ちに空気の供給を受けない状態となって酸化反応が停止し、生じた熱は水蒸気改質反応で消費されるため、それ以上温度が上昇することがない。また、空気の供給を受けずに水蒸気反応によって熱が消費されたセルでは、直ちに空気が供給されて酸化反応によって熱が生じるため、温度が低下しすぎてしまうことがない。

【0156】なお、改質器140において、供給されるメタノール量と空気量との比は、既述した実施例と同様に、改質器内で進行する水蒸気改質反応で要する熱量と、酸化反応で生じる熱量とから定まるため一定である。ここで、本実施例の改質器140では、空気の供給を受けるセルは、常に、ハニカムを構成するセル全体の約半分である。したがって、各セルが空気の供給を受ける際には、メタノール量に対して通常よりも過剰な量の酸素を供給されることになり、供給されたメタノールを水蒸気改質するのに要する熱以上の熱を生じる酸化反応が起こる。しかしながら、上述したように、これらのセルは直ちに空気の供給が停止されるため、空気が供給された上流側で温度が上昇しすぎることがない。また、酸素が過剰な状態で空気と原料ガスが供給されるため、通常の濃度の酸素を供給する場合より、酸化反応が起きる領域がより下流側にまで広がる。したがって、従来の改質器のように下流側で温度が低下しすぎることがない。このように、改質器140では、反応部全体を所定の温度範囲に保ち、水蒸気改質反応の活性を高い状態に保つと共に、水蒸気改質反応の速度を向上させることができる。

【0157】図23は、ハニカムを構成するセル全体に、常に所定の割合の酸素を供給する従来知られる改質器と、上述した改質器140とについて、上流側から下流側への内部の温度分布状態を表わした説明図である。この温度分布状態の測定は、改質器140に供給するガスにおいて、 $LHSV$ （一時間に処理するメタノール体積/触媒体積）=3、酸素/メタノールの比が11%となる空気、水/メタノールの比が2となる水を含む条件において行なった。改質器140は、従来の改質器とは異なり、上流側で温度が上昇しすぎてしまうことがなく、改質器の内部温度を250~300℃の温度範囲で均一化することができる。したがって、本実施例の改質器140は、温度上昇に起因する既述した触媒劣化や副生成物の発生といった不都合を防止することができ、既述した実施例と同様に、改質器の耐久性を大きく向上させることが可能となる。なお、上記した条件において改質器140を用いて燃料ガスを生成すると、 $H_2 = 50\%$ 、 $CO_2 = 23\%$ 、 $H_2O = 17.5\%$ 、 $N_2 = 9\%$ 、 $CO = 0.5\%$ となる燃料ガスが得られ、良好に作動することが確かめられた。

【0158】以上説明した第7実施例の改質器140

は、空気が供給される吹き出し口142が固定され、改質器140が回転する構成としたが、吹き出し口が回転し、改質器が固定された構成とすることもできる。このような構成の改質器を、第7実施例の変形例として以下に示す。図24は、第7実施例の変形例である改質器140Aの構成を模式的に表わす説明図である。改質器140Aは、改質器140とほぼ同様の構成を備えており、対応する部材には同一の番号に符号Aを付して説明する。この改質器140Aにおいては、改質器140Aは回転することがない。また、空気供給路39における吹き出し口142Aに至る端部側において設けられた既述した湾曲部には、所定の回転機構144が設けられている。この回転機構144によって、吹き出し口142Aを備えた空気供給路39の端部は回転し、反応部141Aの上流側端部面において、吹き出し口142Aから空気が供給される領域が経時的に変化する。

【0159】このように構成された改質器140Aを用いる場合にも、第7実施例の改質器140と同様の効果を奏することができる。なお、空気供給路39の端部付近に設けられた回転機構144は、吹き出し口142Aを備える端部部材143と、空気供給路39の基部とを回転自在に支持する構成とし、上記端部部材143は、吹き出し口142Aから空気が吹き出される反力によって回転することとしてもよいし、外部から供給される所定の動力を用いて回転力を発生することとしてもよい。

【0160】なお、上記実施例では、空気の吹き出し口と改質器とのうちのいずれかを回転させることとしたが、改質器の上流部に複数の空気供給口を設け、実際に空気が供給される空気供給口を経時的に切り替える構成としてもよく、反応部において空気が供給される部位を経時的に変化させることができればよい。また、上記改質器140および改質器140Aは、ハニカムによって構成された反応部を有することとしたが、それぞれの反応部は、触媒を担持するペレットを充填することによって構成してもよい。この場合にも、反応部において空気が供給される部位を経時的に変化させることによって、実施例と同様の効果を得ることができる。

【0161】さらに、既述した第6実施例および第7実施例の改質器は、上記した効果の他に、始動時において内部でより多くの酸化反応を進行させ、改質器をより速く定常状態にまで昇温させることができるという効果をも奏する。始動時には改質器の温度が室温付近にまで低下しているため、速やかに昇温させて定常状態にする必要がある。ここで、メタノールおよび酸素を大量に供給して積極的に酸化反応を起こさせ、改質器を内部から加熱する方法が考えられるが、従来の改質器では、多量の空気を供給して酸化反応を起こさせると、改質器全体の温度が低い場合であっても、上流の特定領域だけが昇温しすぎてしまうおそれがあった。上記第6および第7実施例の改質器によれば、酸化反応が活発に進行する領域

(酸素が高い濃度で供給される触媒部位)が経時的に変化するため、多量の酸素を供給して積極的に酸化反応を行なわせても、特定部位だけが昇温しすぎることがなく、速やかに改質器を昇温させることが可能となる。

【0162】次に、第8実施例として、改質器内に複数の反応部を設け、これらの反応部の一部について残りの反応部とはガスの流れを逆向きにすることによって、隣接する反応部の間で、原燃料ガスおよび空気が供給される上流側と、燃料ガスが排出される下流側とで熱交換させる構成を示す。図25は、第8実施例の改質器150の構成を表わす断面模式図である。改質器150は、図1の燃料電池装置20と同様の燃料電池装置に備えられている。この改質器150は、略円柱状に形成されており、その内壁に沿って環状に反応部152を備え、反応部152の内側に反応部151を備えており、2重管状の構造を有している。反応部151は、その一端側(図25中向かって左側)から原燃料ガスおよび空気の供給を受け、他端側(図25中向かって右側)において燃料ガスを排出する。反応部152も一方の端部側から原燃料ガスおよび空気の供給を受け、他方の端部において燃料ガスを排出するが、それぞれの位置は反応部151とは逆である。したがって、反応部151と反応部152では、内部のガスの流れの方向が逆向きになる。ここで、それぞれの反応部151および反応部152は、表面にCu-Zn触媒を担持するハニカムによって構成してもよいし、Cu-Zn触媒からなるペレットを充填して形成してもよい。

【0163】以上のように構成された第8実施例の改質器150によれば、内側に設けた反応部151の上流側と外側に設けた反応部152の下流側、および、反応部151の下流側と反応部152の上流側とが隣接した状態となるため、それぞれ、上流側と下流側との間で熱交換を行なうことが可能となる。したがって、一方の反応部の上流側において酸化反応のために生じた熱は、隣接する他方の反応部の下流側に伝えられ(図25中の点線矢印参照)、原燃料ガスと共に空気を供給される上流側で温度が上昇しすぎることがない。

【0164】また、改質器150を構成する各反応部の下流側では、上述したように、隣接する反応部の上流側から熱が供給されるため、従来の改質器のように下流側で温度が低下しすぎることがない。したがって、改質器150では、各反応部全体において水蒸気改質反応の活性が高い状態に保たれ、水蒸気改質反応の速度を向上させることができる。

【0165】図26は、改質器が備える反応部において内部のガスの流れの方向が一定である従来知られる改質器と、上述した改質器150とについて、一端側から他端側への内部の温度分布状態を、各反応部ごとに表わした説明図である。改質器150は、従来の改質器とは異なり、特定の上流側において酸化反応で生じた熱によ

て昇温しすぎることがなく、また、特定の下流側において内部の温度が低下しすぎることがないため、改質器の内部温度を250~300℃の温度範囲で均一化することができる。以上説明したように、本実施例の改質器150は、その入り口付近で温度が急激に上昇してしまうことがないため、温度上昇に起因する既述した触媒劣化や副生成物の発生といった不都合を防止することができる。したがって、既述した実施例と同様に、改質器の耐久性を大きく向上させることが可能となる。

10 【0166】以上説明した第8実施例の改質器150は、内側に形成された反応部151と外側に形成された反応部152とを備える2重管タイプとし、それぞれの反応部においてガスの流れの方向が逆になる構成としたが、改質器を複数の反応部によって構成し、それらのうち、一部の反応部において、残りの反応部とはガスの流れの方向が逆になる構成とすれば、発熱量が多い上流側と熱の消費量が多い下流側との間で熱交換を行なうことができ、上記第8実施例と同様の所定の効果を得ることができる。例えば、改質器を2重管タイプとする代わりに、20 複数の薄型の反応部を積層した積層タイプとし、これら積層した各反応部について交互にガスの流れの方向が逆向きになる構成としてもよい。このような場合にも、隣接する反応部間において、上流側と下流側とで熱交換を行ない、内部温度を均熱化することができる。

【0167】次に、第9実施例として、所定の反応部が形成する流路において途中で折り返し部を形成し、この所定の反応部において上流側と下流側とを隣接させて熱交換を行なわせる構成を示す。図27は、第9実施例の改質器160の構成を表わす断面模式図である。改質器160は、図1の燃料電池装置20と同様の燃料電池装置に備えられている。この改質器160は、第8実施例の改質器150と同様に略円柱状に形成されており、その内部は内側部161と外側部162とに分かれた2重管構造となっている、これら内側部161および外側部162は連続した構造として形成されており、両者は単一の反応部163を構成している。

【0168】第2燃料供給路64は内側部161の一端に接続されており、第2燃料供給路64から供給される原燃料ガスおよび空気は、内側部161において一端側から他端側に向かって移動する。内側部161の他端では、内側部161は外側部162と接続しており、内側部161内を通過するガスは、上記他端において外側部162に導入される(図27中の実線矢印参照)。外側部162内に導入されたガスは、そのまま外側部162内を通過して、内側部161における上記一端側に対応する端部において第3燃料供給路65に接続し、反応部163内をガスが通過する際に生成した燃料ガスを、この第3燃料供給路65に排出する。なお、反応部163を構成する内側部161および外側部162は、Cu-Zn触媒を担持するハニカムによって構成してもよい

し、Cu-Zn触媒からなるペレットを充填して形成してもよい。

【0169】以上のように構成された第9実施例の改質器160によれば、内側に設けた内側部161と外側に設けた外側部162とが隣接した状態となるため、これら内側部161と外側部162との間で熱交換を行なうことが可能となる。内側部161は、反応部163では上流側に相当し、酸化反応が活発に行なわれて多くの熱が生じる。また、外側部162は、反応部163では下流側に相当し、主として水蒸気改質反応だけが行なわれて熱を要する。改質器160では、多くの熱を生じる内側部161から、熱を要する外側部162に対して熱が伝えられるため、(図27中の点線矢印参照)上流側に相当する内側部161において温度が上昇しすぎてしま

うことがない。

【0170】また、改質器160において、下流側に相当する外側部162では、上述したように、隣接する内側部161から熱が供給されるため、従来の改質器のように下流側で温度が低下しすぎることがない。したがって、改質器160では、各反応部全体において水蒸気改質反応の活性が高い状態に保たれ、水蒸気改質反応の速度を向上させることができる。

【0171】図28は、改質器が備える反応部において内部のガスの流れの方向が一定である従来知られる改質器と、上述した改質器160とについて、第2燃料供給路64との接続側から他端側への内部の温度分布状態を表わした説明図である。改質器160は、従来の改質器とは異なり、上流側において酸化反応で生じた熱によって昇温しすぎることがなく、また、下流側において内部の温度が低下しすぎることがないため、改質器の内部温度を250〜300℃の温度範囲で均一化することができる。以上説明したように、本実施例の改質器160は、その入り口部付近で温度が急激に上昇してしまうことがないため、温度上昇に起因する既述した触媒劣化や副生成物の発生といった不都合を防止することができる。したがって、既述した実施例と同様に、改質器の耐久性を大きく向上させることが可能となる。

【0172】以上説明した第9実施例の改質器160は、内側に形成された内側部161と外側に形成された外側部162とを備える2重管タイプとし、内側部161と外側部162とでガスの流れの方向が逆になる構成としたが、改質器を上記2重管以外の構成としてもよい。原燃料ガスおよび空気が通過する流路において途中で折り返し部を設け、上流側と下流側とを隣接させて両者の間で熱交換が可能な構成とすれば、上記第9実施例と同様の所定の効果を得ることができる。例えば、改質器を2重管タイプとする代わりに、所定の流路を2つに折り畳んだ形状とし、上流側と下流側とでガスの流れの方向が逆向きになる構成としてもよい。このような構成の改質器160Aを図29に示す。このような場合に

も、隣接する上流側から下流側へ熱が伝えられ(図29中の矢印参照)、内部温度を均熱化することができる。

【0173】次に、第10実施例として、蒸発器32から排出される高温の燃焼排ガスをを用いて、改質器の下流側を加熱する構成を示す。図30は、第10実施例の改質器170の構成を表わす断面模式図である。改質器170は、図1の燃料電池装置20と同様の燃料電池装置に備えられている。この改質器170は、表面にCu-Zn触媒を担持するハニカムによって構成された2つの反応部171、172を備えている。このように改質器170内部を2つの反応部に分割することによって、上流側の反応部171においてハニカムの各セルによって分離されたガスを、途中で混合し直すことができ、反応部170内を通過するガスの状態をより均一にすることができる。改質器170は、空気供給路39から空気を供給される第2燃料供給路64と接続し、空気を含有する原燃料ガスの供給を受ける。空気を含有し第2燃料供給路64から供給された原燃料ガスは、反応部171、172の順で通過し、水素リッチな燃料ガスとなって第3燃料供給路65に排出される。

【0174】また、反応部171、172には、温度センサ173、174がそれぞれ設けられている。これら温度センサ173、174は制御部50に接続されており、反応部171、172の内部温度に関する情報は、制御部50に伝えられる。後述するように、温度センサ173の検出結果は、反応部171の内部温度が上昇しすぎるのを防ぐために用いられ、温度センサ174の検出結果は、反応部172の内部温度が低下しすぎるのを防ぐために用いられる。したがって、温度センサ173は、反応部171のより上流側に、温度センサ174は、反応部172のより下流側に設けることが望ましい。

【0175】また、改質器170において、反応部172が設けられている位置に対応する外周部には、既述した蒸発器32から排出される燃焼排ガスが導入される排ガス導入部175が設けられている。蒸発器32では、既述したように、圧縮機28を経由して、燃焼排ガスがバーナ26から供給され、この燃焼排ガスの有する熱量を利用してメタノールおよび水を昇温・気化させる。このようにメタノールおよび水を昇温・気化させた後に圧縮機28から排出される燃焼排ガスは、蒸発器32で熱量を消費した後であっても所定の熱量を有しており、本実施例の改質器170では、この燃焼排ガスを上記排ガス導入部175に導入することによって、下流側に設けた反応部172を加熱している。

【0176】本実施例の改質器170を備える燃料電池装置には、蒸発器32から排出される燃焼排ガスを排ガス導入部175に供給する燃焼排ガス路176が設けられており、この燃焼排ガス路176には、排ガス導入部175に供給する燃焼排ガスの量を調節するマスフロ

ントローラ 177 が設けられている。マスフロコントローラ 177 は、制御部 50 に接続されており、制御部 50 によって、排ガス導入部 175 に供給される燃焼排ガス量が制御可能となっている。ここで、蒸発器 32 から排ガス導入部 175 に供給される燃焼排ガスの温度は、約 300℃ 程度であり、マスフロコントローラ 177 の駆動状態を制御して、排ガス導入部 175 に供給する燃焼排ガス量を調節することによって、反応部 172 の内部温度を制御することができる。上記したように排ガス導入部 175 に導入された燃焼排ガスは、反応部 172 を加熱した後、燃料電池装置の外部に排出される。

【0177】本実施例の改質器 170 における上流側の反応部 171 では、この反応部 171 で進行する水蒸気改質反応に要する熱量は、酸化反応で生じた熱量によって賄っている。これに対し、下流側の反応部 172 では、この反応部 172 で進行する水蒸気改質反応に要する熱量としては、上流側で進行する酸化反応で生じた熱量に加えて、排ガス導入部 175 に供給される上記燃焼排ガスの有する熱が用いられる。ここで、本実施例の改質器 170 を備える燃料電池装置において、制御部 50 は、改質器 170 に供給する空気を取り込むブロウ 38 の駆動量を、温度センサ 173 の検出結果に基づいて制御しており、反応部 171 の内部温度が 300℃ を越えないように、改質器 170 に供給する空気量を調節している。また、同じく本実施例の燃料電池装置において、制御部 50 は、上記マスフロコントローラ 177 の駆動量を、温度センサ 174 の検出結果に基づいて制御しており、反応部 172 の内部温度が 250℃ 以上となるように、排ガス導入部 175 に供給する燃焼排ガス量を調節している。

【0178】以上のように構成された第 10 実施例の改質器 170 によれば、下流側の反応部 172 は、既述した燃焼排ガスによって加熱されるため、改質器 170 内で進行する水蒸気改質反応で要する熱量のすべてを酸化反応で生じる熱量によって賄う必要はなく、酸化反応に供するために改質器 170 に供する空気の量を減らし、上流側で進行する酸化反応の量を減らすことができる。ここで、改質器 170 に供給する空気量は、反応部 171 の内部温度に基づいて調節されるため、酸化反応が活発に行なわれる反応部 171 において温度が上昇しすぎ

てしまうことがない。

【0179】また、改質器 170 において、下流側の反応部 172 では、上述したように、排ガス導入部 175 に導入される燃焼排ガスから熱が供給されるため、従来の改質器のように下流側で温度が低下しすぎることがない。したがって、改質器 170 では、各反応部全体において水蒸気改質反応の活性が高い状態に保たれ、水蒸気改質反応の速度を向上させることができる。さらに、反応部 172 を加熱するために、従来廃棄されていた燃料排ガスの熱を利用しているため、反応部 172 を加熱す

ることによってエネルギー効率が低下してしまうことがない。

【0180】図 31 は、水蒸気改質反応で要する熱量の略全体を、酸化反応で生じる熱によって賄う従来知られる改質器と、上述した改質器 170 とについて、空気を含む原燃料ガスが供給される上流側から下流側への内部の温度分布状態を表わした説明図である。改質器 170 は、従来の改質器とは異なり、上流側において酸化反応で生じた熱によって昇温しすぎることがなく、また、下流側において内部の温度が低下しすぎることがないため、改質器の内部温度を 250～300℃ の温度範囲で均一化することができる。以上説明したように、本実施例の改質器 170 は、その入り口付近で温度が急激に上昇してしまうことがないため、温度上昇に起因する既述した触媒劣化や副生成物の発生といった不都合を防止することができる。したがって、既述した実施例と同様に、改質器の耐久性を大きく向上させることが可能となる。

【0181】以上説明した第 10 実施例の改質器 170 は、ハニカムによって構成された 2 つの反応部 171、172 を備えることとしたが、ハニカムを用いる代わりに、触媒を担持したペレットを内部に充填する構成としてもよい。この場合には、改質器内部を 2 つに分けることなく、改質器内部に均一にペレットを充填することとしても差し支えない。

【0182】また、下流側を加熱するために、蒸発器 32 から排出される燃焼排ガス以外の高温ガスを用いることとしてもよい。例えば、本実施例の改質器 170 を備える燃料電池装置において、蒸発器 32 で要する熱を供給する熱源と、燃料電池 40 の陰極側に圧縮空気を供給するための圧縮機 28 の駆動源が異なる場合には、上記熱源と上記駆動源のうち、いずれから排出される排ガスをを用いることとしてもよい。また、燃料電池装置を構成する他の高温部から排出されるガスをを用いることとしてもよく、改質器の内部温度を 250～300℃ の温度範囲に保つために使用可能なエネルギーを有していればよい。あるいは、高温の部材から排出される高温の排ガスをを用いる代わりに、高温の部材と改質器との間に所定の流体を循環させ、この流体によって高温の部材の熱エネルギーを改質器に供給することとしてもよい。

【0183】次に、第 11 実施例として、改質器の上流側において原燃料の一部を液体の状態で供給する構成を示す。図 32 は、第 11 実施例の改質器 180 の構成の概要を表わす説明図である。改質器 180 は、図 1 の燃料電池装置 20 と同様の燃料電池装置に備えられている。この改質器 180 は、表面に Cu-Zn 触媒を担持するハニカムによって構成された単一の反応部 181 を備えている。ここで、改質器 180 は、第 2 燃料供給路 64 と接続して原燃料ガスの供給を受けるが、その他に、メタノールと水との混合液（以下、液体原燃料と呼

ぶ)の供給を受ける。液体原燃料は、既述したように、第1燃料供給路63を介して蒸発器32に供給されるが、この第1燃料供給路63は途中で分岐して原燃料分岐路182となり、改質器180に対しても液体原燃料が供給可能となっている。さらに、本実施例では、空気供給路39は、第2燃料供給路64とは合流せずに、上記原燃料分岐路182と合流して原燃料路183となる。この原燃料路183は、改質器180の上流側端部に接続しており、空気を混合された液体原燃料が改質器180に供給可能となっている。

【0184】なお、空気供給路39にはマスフロコントローラ184が、原燃料分岐路182にはマスフロコントローラ185が設けられており、改質器180に供給する空気量および液体原燃料の量を制御可能となっている。これらのマスフロコントローラ184、185は制御部50に接続されており、制御部50によってその駆動量が制御される。また、改質器180内部において、反応部181の上流側端部の近傍には、原燃料路183の端部構造として噴射ノズル187が設けられている。上記したように空気を混合された液体原燃料は、この噴射ノズル187から、空気の圧力を利用して反応部181の端部に向かって噴射され、反応部181の端部断面に対して広い範囲で供給される。なお、噴射ノズル187は、液体を広い範囲に噴射可能な形状であればよく、ノズル状以外の形状としても構わない。さらに、改質器180において、反応部181の上流側端部付近には、温度センサ186が設けられている。この温度センサ186は、制御部50に接続されており、反応部181の上流側の温度に関する情報が制御部50に入力される。

【0185】既述したように、改質器に対して原燃料ガスと共に空気を供給すると、酸素の濃度が高い上流側では、酸化反応が活発に進行して温度が上昇するが、本実施例では、反応部181の上流側に対して液体原燃料を噴射することによって、この上流側の温度を制御している。すなわち、所定の高温となっている反応部181に対して液体原燃料を噴射すると、液体原燃料は、噴射された反応部181から熱を奪って気化・昇温する。したがって、この液体原燃料の供給量を調節することによって、反応部181の上流側の温度を所定の温度以下に制御することができる。

【0186】このような構成の改質器180を用いて水素リッチな燃料ガスの生成を行なう際には、温度センサ186が検出した反応部181内の温度に基づいて、改質器180に対して液体原燃料量を供給するかどうか、あるいはその供給量が制御される。改質器180に供給されるメタノールの総量は、燃料電池40に接続される負荷の大きさ、すなわち、燃料電池40に供給すべき燃料ガス量に基づいて決定されるが、温度センサ186の検出結果に基づいて、第1燃料供給路63から液体のまま改質器180に供給されるメタノール量が調節され

る。具体的には、反応部181の温度が所定の温度(本実施例では300℃)を越えると、噴射ノズル187から液体原燃料の噴射を行なうようになり、反応部181の温度が上記所定の温度以下となるように、噴射ノズル187から供給する液体原燃料の量を調節する。なお、反応部181の温度が上記所定の温度以下の場合には、噴射ノズル187からは、空気だけが噴射される。

【0187】以上のように構成された第1実施例の改質器180によれば、改質器180内で液体を噴射して気化させることによって、反応部181の上流部を冷却することができるため、酸化反応で生じる熱のために反応部181の上流部の温度が上昇しすぎてしまうのを防ぐことができる。ここで、反応部181の上流部を冷却するために改質器180中で噴射する液体は、改質器180内で進行する水蒸気改質反応および酸化反応で利用される原燃料からなるため、このような液体噴射の操作を行なうことによって、改質器180内で進行する反応が影響を受けることがない。

【0188】図33は、所望の量の燃料ガスを生成するために要するメタノールの全量を、蒸発器32を経由して供給される従来知られる改質器と、上述した改質器180とについて、空気を含む原燃料ガスが供給される上流側から下流側への内部の温度分布状態を表わした説明図である。改質器180は、従来の改質器とは異なり、上流側において酸化反応で生じた熱によって昇温しすぎることがないため、改質器の内部温度を250~300℃の温度範囲で均一化することができる。このように、本実施例の改質器180は、その入り口部付近で温度が急激に上昇してしまうことがないため、温度上昇に起因する既述した触媒劣化や副生成物の発生といった不都合を防止することができる。したがって、既述した実施例と同様に、改質器の耐久性を大きく向上させることが可能となる。

【0189】なお、改質器180の上流側の温度が上昇しすぎて噴射ノズル187から噴射する液体原燃料量を増やした際に、燃料電池40に接続される負荷における所要電力が減少すると、改質器180に供給するメタノール量が過剰となって、必要量以上の燃料ガスが生成される場合がある。本実施例の改質器180を備える燃料電池装置では、燃料電池40から排出される燃料排ガスは、既述したようにパーナ26における燃焼のための燃料として利用されるため、上記した場合であっても、システム全体のエネルギー効率が低下してしまうことがない。

【0190】また、本実施例の改質器180では、反応部181の上流部を冷却するために噴射ノズル187から噴射するのは、メタノールと水との混合液としたが、メタノールあるいは水だけを噴射する構成としてもよい。この場合には、第1燃料供給路63の代わりに、メタノール流路60あるいは水供給路62において分岐路

を設け、この分岐路によって、噴射ノズル187と同様のノズルに対してメタノールあるいは水を供給することとすればよい。このような構成としても、反応部181の上流部において、噴射された液体が気化する際に熱を奪うため、上記第11実施例の改質器180と同様の効果を得ることができる。

【0191】次に、第12実施例として、水蒸気改質反応と酸化反応との両方が進行する反応部と、水蒸気改質反応だけが進行する反応部とを隣接して設け、両者の間で熱交換を行なわせて、酸化反応で生じる熱によって過度の温度上昇が引き起こされるのを防止する構成を示す。図34は、第12実施例の改質器190の構成の概要を表わす説明図である。改質器190は、図1の燃料電池装置20と同様の燃料電池装置に備えられている。この改質器190は、略円柱状に形成されており、ハニカムによって構成された3つの反応部191、192、193を備えている。改質器190の内壁に沿って、環状に反応部193が形成されており、この反応部193の内側に、反応部191、192が形成されている。ここで、反応部191は上流側、反応部192は下流側に設けられており、両者の間には所定の空間200が形成されている。

【0192】この改質器190において、反応部191、192、193は、いずれも、既述したCu-Zn触媒を表面に担持している。ここで、反応部193は、第2燃料供給路64と接続しており、原燃料ガスを供給されるが、空気の供給は受けないため、反応部193においては水蒸気改質反応は行なわれる、酸化反応は行なわれない。第2燃料供給路64は、上記反応部193の他に反応部191にも接続しており、反応部191に供給された原燃料ガスは、反応部191、反応部192の順で内部を通過する。また、空気供給路39は、途中で空気分岐路194、195に分岐し、これらの空気分岐路は、それぞれ反応部191および反応部192の上流側に接続する。これらの空気分岐路194、195は、それぞれの反応部に対して空気を供給する。したがって、反応部191および反応部192では、水蒸気改質反応と共に酸化反応が進行する。反応部191、192における水蒸気改質反応および酸化反応によって生じた水素リッチガスと、反応部193における水蒸気改質反応によって生じた水素リッチガスとは、第3燃料供給路65へ排出されてCO低減部36に供給される。

【0193】また、空気供給路39から分岐する空気分岐路194、195には、それぞれマスフローコントローラ196、197が設けられており、反応部191、192に供給する空気量を調節可能となっている。これらマスフローコントローラ196、197は制御部50に接続されており、制御部50によって、各反応部に供給される空気量が制御される。また、反応部191、192それぞれの上流側には、各反応部の内部温度を検出す

る温度センサ198、199が設けられている。これらの温度センサ198、199は制御部50に接続されており、各反応部の内部温度を検出した結果は制御部50に入力される。制御部50は、各温度センサから入力される上記検出結果に基づいて、各反応部に供給する空気量を制御する。

【0194】本実施例の改質器190における反応部191、192では、内部で進行する水蒸気改質反応に要する熱量は、同じく内部で進行する酸化反応で生じた熱量によって賄っている。これに対し、外周部に設けた反応部193では、この反応部193で進行する水蒸気改質反応に要する熱は、内側に隣接する反応部191、192における酸化反応で生じた熱を利用している（図34中の点線矢印参照）。ここで、本実施例の改質器190を備える燃料電池装置において、制御部50は、反応部191、192に供給する空気量を調節するマスフローコントローラ196、197の駆動量を、温度センサ198、199の検出結果に基づいて制御しており、反応部191、192の内部温度が300℃を越えないように、供給する空気量を調節している。

【0195】以上のように構成された第12実施例の改質器190によれば、反応部191、192で進行する酸化反応で生じた熱は、隣接する反応部であって吸熱反応だけが進行する反応部193においても消費される。したがって、酸化反応が活発に進行する反応部191、192の上流部において、過度に温度が上昇してしまうのを防ぐことができる。ここで反応部191、192に供給する空気量は、各反応部の内部温度に基づいて調節されるため、各反応部の内部温度を所定の温度以下に保つよう制御することができる。

【0196】また、本実施例の改質器190では、反応部191、192のそれぞれに対して空気を供給しているため、反応部191の下流側に位置する反応部192においても発熱反応である酸化反応を行なわせることができ、従来の改質器のように下流側で温度が低下しすぎることがない。したがって、改質器190では、各反応部全体において水蒸気改質反応の活性が高い状態に保たれ、水蒸気改質反応の速度を向上させることができる。

【0197】図35は、水蒸気改質反応と酸化反応との両方を進行させる反応部によってのみ構成された従来知られる改質器と、上述した改質器190とについて、原燃料ガスが供給される上流側から下流側への内部の温度分布状態を表わした説明図である。改質器190は、従来の改質器とは異なり、上流側において酸化反応で生じた熱によって昇温しすぎることがなく、また、下流側において内部の温度が低下しすぎることがないため、改質器の内部温度を250～300℃の温度範囲で均一化することができる。以上説明したように、本実施例の改質器190は、その入り口部付近で温度が急激に上昇してしまうことがないため、温度上昇に起因する既述した触

媒劣化や副生成物の発生といった不都合を防止することができる。したがって、既述した実施例と同様に、改質器の耐久性を大きく向上させることが可能となる。

【0198】なお、上記第12実施例の改質器190では、内側に設けられて水蒸気改質反応と酸化反応との両方を進行する反応部191、192において、それぞれに対して空気を供給する構成としたため、下流側において温度が低下するのを抑える効果を大きくすることができたが、空気の供給を上流側だけから行なう場合にも、上流側における過度の温度上昇を抑える所定の効果を得ることができる。

【0199】上記第12実施例の改質器190は、水蒸気改質反応と酸化反応との両方を行なう反応部と、水蒸気改質反応だけを行なう反応部とは、内側と外周部とに分かれており、2重管型に形成したが、以下に、第12実施例の変形例として、上記2種類の反応部を交互に積層する積層型の構成を示す。図36は、第12実施例の変形例である改質器190Aの構成の概略を模式的に示す説明図である。改質器190Aは、改質器190と同様に図1の燃料電池装置20と同様の燃料電池装置に備えられており、改質器190と共通する部材には部材番号に符号Aを付して以下の説明を行なう。

【0200】改質器190Aは、それぞれ平板型に形成された反応部191Aと反応部193Aとを交互に複数個積層した構造を有している。これらの反応部191Aおよび193Aは、表面にCu-Zn触媒を担持したハニカムによって構成されており、各反応部に対しては、第2燃料供給路64から原燃料ガスが供給される。また、空気供給路39は、分岐してそれぞれの反応部191Aの上流部に接続し、各反応部191Aに対して空気を供給する。複数の反応部191Aに対して供給する空気量は、空気供給路39に設けられたマスフローコントローラ196Aによって制御されるが、この制御は、第12実施例と同様に、各反応部191Aの上流部に設けた温度センサ（図示せず）による検出結果に基づいて行なわれる。

【0201】以上のように構成された第12実施例の変形例である改質器190Aによれば、第12実施例の改質器190と同様に、酸化反応で生じた熱は隣接する反応部で進行する水蒸気改質反応で消費されるため、酸化反応が活発に進行する上流部の温度が過度に上昇してしまうことがない。したがって、改質器190と同様に、触媒劣化や副生成物の発生といった不都合を防止し、改質器の耐久性を大きく向上させることができるという効果を得ることができる。

【0202】次に、第12実施例の第2の変形例として、多管挿入型の改質器190Bを示す。図37は、第12実施例の第2の変形例である改質器190Bの構成の概略を表わす断面模式図である。図37(A)は、改質器190Bの縦断面図、図37(B)は、図37

(A)のB-B線における横断面図である。改質器190Bは、改質器190と同様に図1の燃料電池装置20と同様の燃料電池装置に備えられており、改質器190と共通する部材には部材番号に符号Bを付して以下の説明を行なう。

【0203】改質器190Bは、略円柱状に形成されており、その内部に反応部191Bと反応部193Bとを備えている。反応部191Bは、底面の直径が短い略円柱状に形成されており、改質器190B内に7個が形成されている。改質器190B内において、反応部191Bが形成されていない空間は、反応部193Bを構成している。これらの反応部191Bおよび193Bは、表面にCu-Zn触媒を担持したハニカムによって構成されており、各反応部に対しては、第2燃料供給路64から原燃料ガスが供給される。また、空気供給路39は、分岐してそれぞれの反応部191Bの上流部に接続し、各反応部191Bに対して空気を供給する。複数の反応部191Bに対して供給する空気量は、空気供給路39に設けられたマスフローコントローラ196Bによって制御されるが、この制御は、第12実施例と同様に、各反応部191Bの上流部に設けた温度センサ（図示せず）による検出結果に基づいて行なわれる。

【0204】以上のように構成された第12実施例の変形例である改質器190Bによれば、第12実施例の改質器190と同様に、酸化反応で生じた熱は隣接する反応部で進行する水蒸気改質反応で消費されるため、酸化反応が活発に進行する上流部の温度が過度に上昇してしまうことがない。したがって、改質器190と同様に、触媒劣化や副生成物の発生といった不都合を防止し、改質器の耐久性を大きく向上させることができるという効果を得ることができる。

【0205】上記した改質器190、190A、190Bでは、酸化反応を限られた反応部において行なわせている。改質器内で進行する水蒸気改質反応で要する熱が一定である場合に、酸化反応が進行する領域を小さくすると、供給した酸素量に比べて触媒量が不足した状態となり、酸素が供給される領域における酸化反応の速度を抑えることができる。したがって、酸化反応が進行する領域をより下流側に広げることができ、改質器の下流側において温度が低下しすぎるのを抑える効果をより大きくすることができる。

【0206】なお、上記した第12実施例の変形例である改質器190A、190Bにおいて、改質器190と同様に、改質器の上流側に加えてその中程でも空気を供給する構成としてもよい。このような構成とすれば、改質器の下流側で温度が下降しすぎるのを防ぐことができる。また、上記改質器190、190A、190Bのそれぞれを構成する各反応部は、ハニカムによって構成したが、触媒を担持したペレットを充填する構成としても構わない。この場合にも、水蒸気改質反応と共に酸化反

59

応を進行する反応部と、水蒸気改質反応だけを進行する反応部とを隣接させることによって、反応部の上流側で温度が上昇しすぎてしまうのを防ぐことができる。

【0207】既述した第1ないし第12実施例では、それぞれの改質器が備える触媒として、Cu-Zn触媒を用いているため、単一の触媒によって、(4)式に示した水蒸気改質反応と(5)式に示した酸化反応との両方を促進させることができる。もとより、水蒸気改質反応と酸化反応との両方を促進可能なCu-Zn触媒以外の触媒（例えばPd-Zn触媒など）を用いることとしてもよい。このような触媒を用いる場合にも、この触媒を既述した実施例の改質器に備えさせることによって、改質器内部の一部の領域で内部温度が上昇しすぎてしまうのを抑える既述した効果を得ることができる。

【0208】また、上記それぞれの実施例において、水蒸気改質反応と酸化反応とを単一の触媒によって促進する代わりに、それぞれの反応を異なる触媒を用いて促進する構成としてもよい。あるいは、Cu-Zn触媒に対して、酸化反応を促進する他の触媒をさらに加えて用いることとしても良い。このように、複数の種類の触媒を用いる場合にも、改質器内でのこれらの触媒の混在状態が充分であり、酸素が供給されている領域において、

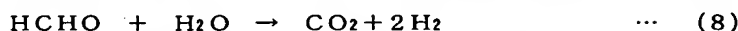
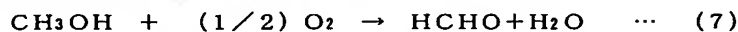
(5)式に示した酸化反応と(4)式に示した水蒸気改質反応との両方が充分な効率で進行可能となるならば、それぞれの実施例の構成において、改質器内部の一部の領域で内部温度が上昇しすぎてしまうのを抑える既述した効果を得ることができる。ここで、酸化反応を促進可能な他の触媒としては、例えば、パラジウム、白金、ニッケル、ロジウム、クロム、タングステン、レニウム、金、銀、鉄などの金属、あるいはこれらの金属と他の金属との合金等を挙げることができる。

【0209】また、既述した実施例では、原燃料としてメタノールを用いることとしたが、他種の炭化水素を原燃料として用い、この原燃料を水蒸気改質反応および酸化反応に供することとしても良い。このようにメタノール以外の原燃料を用いる場合にも、用いる原燃料に応じ*



【0213】Cu-Zn触媒によって、メタノールの水蒸気改質反応、あるいはこれと同時にメタノールの酸化反応を促進させると、既述したように水素と二酸化炭素が生成されるが、水素と二酸化炭素の生成量が増えるに従って、上記(6)式の反応が僅かに進行して一酸化炭素が生成される。その結果、改質器で生成される燃料ガス中には、所定量の一酸化炭素が含有されることになる。

【0214】このように、メタノールを改質するためにCu-Zn触媒を用いることは、所定量の一酸化炭素の※



【0216】(7)式および(8)式に示すように、C

60

*た触媒を、既述した実施例の構成を有する改質器に備えさせることによって、改質器内部の一部の領域で内部温度が上昇しすぎてしまうのを抑える既述した効果を得ることができる。

【0210】なお、既述した第1ないし第12実施例の改質器において備えられたCu-Zn触媒は、メタノールの水蒸気改質反応を促進する触媒としては周知の触媒である。既述したように、Cu-Zn触媒は、300℃を超える高温下では劣化してしまうため、水蒸気改質反応が進行する反応温度が高い炭化水素を原燃料とする場合には、水蒸気改質反応を促進する触媒として用いることはできないが、他の炭化水素に比べて水蒸気改質反応の際の反応温度が低いメタノールを原燃料として用いる場合には、この反応を促進する触媒として良好に働く。しかしながら、このCu-Zn触媒を酸化触媒として用いる使用法は従来知られていなかった。すなわち、Cu-Zn触媒は容易に酸化される性質を持っており（銅が酸化劣化する）、酸素の存在下では速やかに酸化されて触媒活性が損なわれてしまうため、通常は酸化触媒として用いることができない。これに対して、このCu-Zn触媒をメタノールの存在下で用いると、酸化自由エネルギー差から、銅よりもメタノールの方が酸化され易いため、触媒自身は酸化されてしまうことなく、上記両反応を促進する触媒として有効に働くことができる。

【0211】このように、Cu-Zn触媒を用いることによって、単一の触媒で、メタノールの水蒸気改質反応と酸化反応との両方を促進させることができ、改質器の構成を簡素化できるという効果が得られるが、Cu-Zn触媒を用いてメタノールの酸化反応を促進することにより、改質器で生成される水素リッチな燃料ガス中の一酸化炭素濃度をより低くすることができるという効果を、さらに得ることができる。ここで、改質器内で生じる一酸化炭素について説明する。Cu-Zn触媒は、二酸化炭素と水素の存在下では、以下に示す(6)式の反応を僅かに進行させる活性を有する。

【0212】

※生成を伴ってしまうが、既述した実施例のように、水蒸気改質反応と同時に進行するメタノールの酸化反応を促進する触媒としてCu-Zn触媒を用いる場合には、この酸化反応が進行する際に一酸化炭素が生成されないため、燃料ガス中の一酸化炭素濃度の上昇が抑えられる。Cu-Zn触媒によって促進されるメタノールの酸化反応は、既述した(5)式に表わしたが、この反応は、主として、以下の(7)式および(8)式に示す反応からなっており、全体として(5)式の反応が進行する。

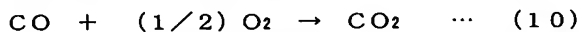
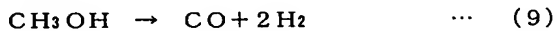
【0215】

50 Cu-Zn触媒によって促進されるメタノールの酸化反応

61

は、主として、一酸化炭素を生じない反応経路を経由する。これに対し、既述した従来知られる酸化触媒、例えば白金触媒によって促進される酸化反応は、主として、以下の(9)式および(10)式に示す反応からなっており、全体として(5)式の反応が進行するため、反応の途中で一酸化炭素が生じてしまう。したがって、白金触媒のような従来知られる酸化触媒を用いてメタノールの酸化反応を促進する場合には、このようにして生じた一酸化炭素の一部が、改質器内で生成される燃料ガス中に残留し、燃料ガス中の一酸化炭素濃度をさらに引き上げてしまう。

【0217】



【0218】既述した実施例のように、Cu-Zn触媒を用いてメタノールの水蒸気改質反応と酸化反応の両方を促進する場合には、その酸化反応は、一酸化炭素を生じない反応経路を経由するため、従来知られる白金などの酸化触媒を用いてメタノールの酸化反応を促進し、Cu-Zn触媒を用いて水蒸気改質反応を促進する場合に比べて、生成される燃料ガス中の一酸化炭素濃度をはるかに低くすることが可能となる。従来知られる白金などの酸化触媒を改質器内に備えさせ、Cu-Zn触媒によってメタノールの水蒸気改質反応を、上記酸化触媒によってメタノールの酸化反応を進行させた場合には、通常は1.5~2%以上の一酸化炭素が燃料ガス中に残留してしまう。これに対し、Cu-Zn触媒だけを用いてメタノールの水蒸気改質反応と酸化反応とを進行させた場合には、燃料ガス中に残留する一酸化炭素濃度を0.5%程度に抑えることが可能となる。

【0219】一酸化炭素が残留する燃料ガスを燃料電池に供給すると、この一酸化炭素は、電解質膜上に設けられた白金を含有する触媒層に吸着し、電気化学反応の進行を阻害してしまう。既述した実施例の燃料電池装置では、改質器の下流にCO低減部を設け、燃料電池に供給する燃料ガス中の一酸化炭素濃度を低減しているが、Cu-Zn触媒を用いてメタノールの酸化反応と水蒸気改質反応とを促進し、改質器で生成される燃料ガス中の一酸化炭素濃度を低減することによって、CO低減部に要求される処理量(CO低減部で酸化すべき一酸化炭素量)が少なくなる。したがって、CO低減部をより小型化しても、充分に一酸化炭素濃度が低い燃料ガスを燃料電池に供給することが可能となる。なお、改質器で生成される燃料ガス中の一酸化炭素濃度が充分に低ければ、CO低減部を設けないこととしても良い。このように、Cu-Zn触媒を用いて、メタノールの水蒸気改質反応とメタノールの酸化反応との両方を促進することによって、改質器で生成される燃料ガス中の一酸化炭素濃度をより低くし、この改質器を備える燃料電池装置全体をコンパクト化することができる。

62

【0220】なお、上記した実施例のCu-Zn触媒では、この触媒を製造する材料として酸化銅(CuO)と酸化亜鉛(ZnO)を用いたが、これらを共沈させる際に、他の物質をさらに加えることとしても良い。例えば、酸化銅と酸化亜鉛を共沈させてCu-Zn触媒を製造する際に、アルミナを2~5%程度加えてもよく、このような構成とすれば、Cu-Zn触媒の耐熱性を向上させ、触媒を形成する銅と酸化亜鉛とのばらつき状態を向上させることができる。

【0221】また、上記した説明では、メタノールの水蒸気改質反応とメタノールの酸化反応との両方を促進する触媒として、酸化銅と酸化亜鉛を材料とするCu-Zn触媒を用いることとしたが、Cu-Zn以外の銅系触媒を用いても、メタノールの水蒸気改質反応と酸化反応とを促進し、一酸化炭素濃度の低い燃料ガスを生成できるという効果を得ることができる。例えば、酸化銅と酸化クロム(Cr₂O₃)を材料として用いたり、酸化銅と酸化ケイ素(SiO₂)を材料として用いたり、あるいは酸化銅と他の金属酸化物を材料として用いても、既述した両反応を促進可能な触媒を得ることができる。このとき、これらの銅系触媒を製造する方法としては、既述した共沈法の他、含浸法や混練法、あるいはイオン交換法など、用いる材料に応じた製造方法を探ればよい。

【0222】以上本発明の実施例について説明したが、本発明はこうした実施例に何等限定されるものではなく、本発明の要旨を逸脱しない範囲内において種々なる状態で実施し得ることは勿論である。

【図面の簡単な説明】

【図1】本発明の好適な一実施例である燃料電池装置200の構成の概略を表わすブロック図である。

【図2】燃料電池40が備える単セル48の構成を表わす断面模式図である。

【図3】改質器34の構成を模式的に表わす説明図である。

【図4】改質器34を構成するハニカムの断面を模式的に表わす説明図である。

【図5】改質器34および従来知られる改質器における内部の温度分布状態を表わす説明図である。

【図6】第1実施例の変形例におけるハニカム断面の様子を表わす説明図である。

【図7】第1実施例の他の変形例である改質器の構成を模式的に表わす説明図である。

【図8】第2実施例の改質器90の構成を模式的に表わす説明図である。

【図9】(A)は、反応部92を構成するハニカムの断面の一部を表わす断面模式図、(B)は、ハニカムの表面の一部をさらに拡大した様子を表わす模式図である。

【図10】改質器90および従来知られる改質器における内部の温度分布状態を表わす説明図である。

【図11】第3実施例の改質器100の構成を模式的に

表わす説明図である。

【図 12】改質器 100 および従来知られる改質器における内部の温度分布状態を表わす説明図である。

【図 13】第 4 実施例の改質器 110 の構成を模式的に表わす説明図である。

【図 14】改質器 110 を備える燃料電池装置で実行される空気混合量制御処理ルーチンを表わすフローチャートである。

【図 15】第 4 実施例の変形例である改質器 110A の構成を模式的に表わす説明図である。

【図 16】改質器 110A および従来知られる改質器における内部の温度分布状態を表わす説明図である。

【図 17】第 5 実施例の改質器 120 の構成を模式的に表わす説明図である。

【図 18】燃料電池 20 において実行されるガス入り口切り替え処理ルーチンを表わすフローチャートである。

【図 19】改質器 120 および従来知られる改質器における内部の温度分布状態を表わす説明図である。

【図 20】第 6 実施例の改質器 130 およびこの改質器 130 と接続される部材の構成を模式的に表わす説明図である。

【図 21】改質器 130 および従来知られる改質器における内部の温度分布状態を表わす説明図である。

【図 22】第 7 実施例の改質器 140 の構成を模式的に表わす説明図である。

【図 23】改質器 140 および従来知られる改質器における内部の温度分布状態を表わす説明図である。

【図 24】第 7 実施例の変形例である改質器 140A の構成を模式的に表わす説明図である。

【図 25】第 8 実施例の改質器 150 の構成を表わす断面模式図である。

【図 26】改質器 150 および従来知られる改質器における内部の温度分布状態を表わす説明図である。

【図 27】第 9 実施例の改質器 160 の構成を表わす断面模式図である。

【図 28】改質器 160 および従来知られる改質器における内部の温度分布状態を表わす説明図である。

【図 29】第 9 実施例の変形例である改質器 160A の構成を模式的に表わす説明図である。

【図 30】第 10 実施例の改質器 170 の構成を表わす断面模式図である。

【図 31】改質器 170 および従来知られる改質器における内部の温度分布状態を表わす説明図である。

【図 32】第 11 実施例の改質器 180 の構成を模式的に表わす説明図である。

【図 33】改質器 180 および従来知られる改質器における内部の温度分布状態を表わす説明図である。

【図 34】第 12 実施例の改質器 190 の構成を模式的に表わす説明図である。

【図 35】改質器 190 および従来知られる改質器にお

ける内部の温度分布状態を表わす説明図である。

【図 36】第 12 実施例の変形例である改質器 190A の構成を模式的に表わす説明図である。

【図 37】第 12 実施例の変形例である改質器 190B の構成を模式的に表わす説明図である。

【図 38】従来の燃料改質装置内部における温度分布の様子を表わす説明図である。

【符号の説明】

20…燃料電池装置

10 22…メタノールタンク

24…水タンク

26…バーナ

28…圧縮機

28a…タービン

28b…コンプレッサ

28c…シャフト

29…空気導入路

32…蒸発器

34, 34A…改質器

20 36…CO低減部

38…ブロワ

39…空気供給路

39A, 39B…空気分岐路

40…燃料電池

41…電解質膜

42…カソード

43…アノード

44, 45…セパレータ

44P…燃料ガス流路

30 45P…酸化ガス流路

48…単セル

50…制御部

52…入出力ポート

54…CPU

56…ROM

58…RAM

60…メタノール流路

61…メタノール分岐路

62…水供給路

63…第 1 燃料供給路

64…第 2 燃料供給路

65…第 3 燃料供給路

66…第 4 燃料供給路

67…燃料排出路

68…酸化ガス供給路

69…酸化排ガス路

69A, 69B…酸化排ガス分岐路

70…第 1 ポンプ

71…第 2 ポンプ

50 72…第 3 ポンプ

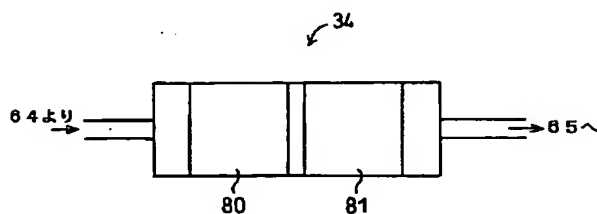
65

73…第1温度センサ
 74…第2温度センサ
 80…第1反応部
 81…第2反応部
 82, 83…ステンレス板
 90…改質器
 92…反応部
 94…ステンレス板
 96…触媒層
 100…改質器
 101…第1反応部
 102…第2反応部
 110…改質器
 110A…改質器
 111, 111A, 111B…反応部
 112, 112A, 112B…マスフロコントローラ
 113, 113A, 113B…マスフロコントローラ
 114…酸素濃度センサ
 115, 115A, 115B…第2空気供給路
 117…温度センサ
 120…改質器
 121…反応部
 122…温度センサ
 123…温度センサ
 124…第1供給分岐路
 125…第2供給分岐路
 126…第1排出分岐路
 127…第2排出分岐路
 128, 129, 128A, 129A…電磁弁
 130…改質器
 132…調圧弁
 134…噴射ノズル
 136…フィルタ
 140, 140A…改質器

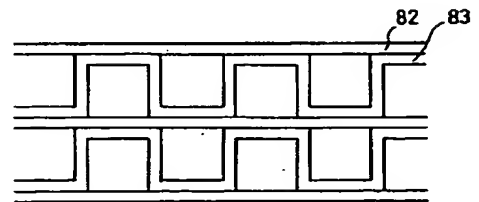
66

141, 141A…反応部
 142, 142A…吹き出し口
 143…端部部材
 144…回転機構
 150…改質器
 151…反応部
 152…反応部
 160, 160A…改質器
 161…内側部
 162…外側部
 163…反応部
 170…改質器
 171, 172…反応部
 171, 172…反応部
 173, 174…温度センサ
 175…排ガス導入部
 176…燃焼排ガス路
 177…マスフロコントローラ
 180…改質器
 181…反応部
 182…原燃料分岐路
 183…原燃料路
 184, 185…マスフロコントローラ
 186…温度センサ
 187…噴射ノズル
 190, 190A, 190B…改質器
 191, 192, 193…反応部
 191A, 193A…反応部
 191B, 193B…反応部
 194, 195…空気分岐路
 196, 197…マスフロコントローラ
 196A, 196B…マスフロコントローラ
 198, 199…温度センサ

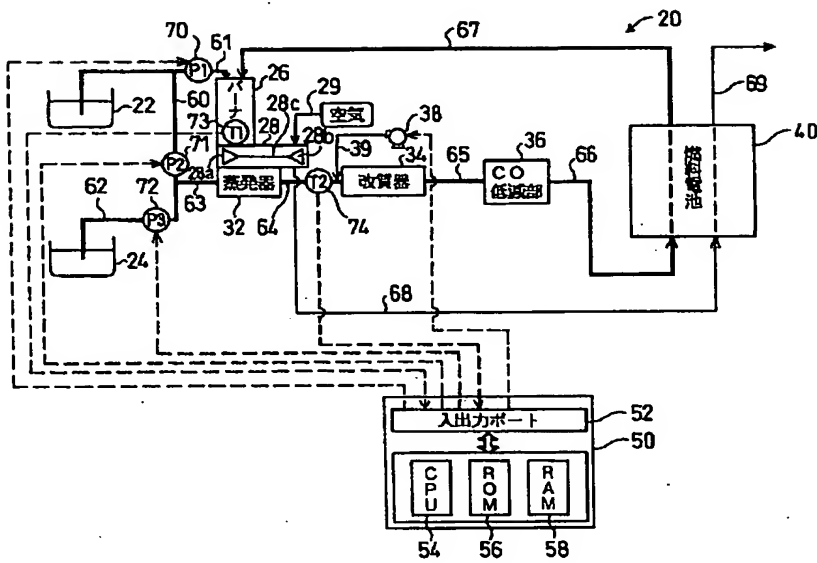
【図3】



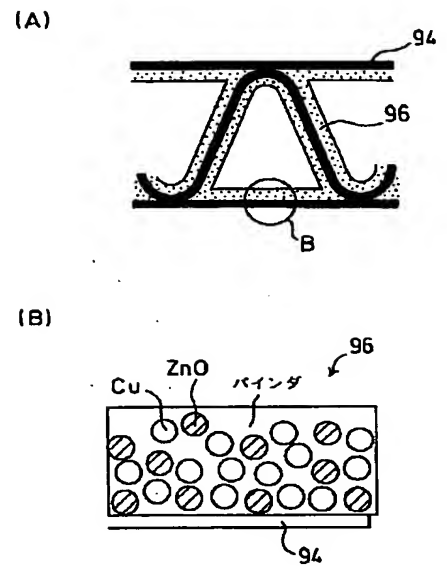
【図4】



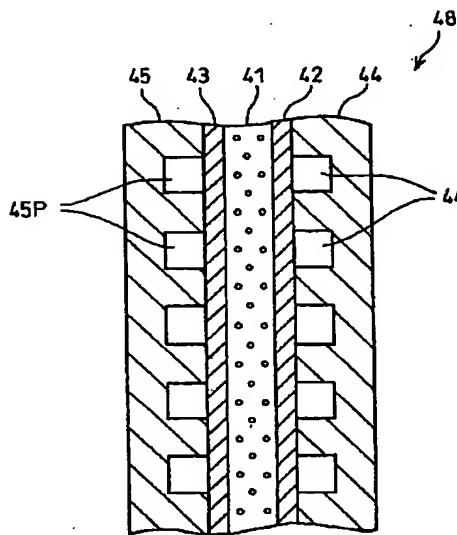
【図1】



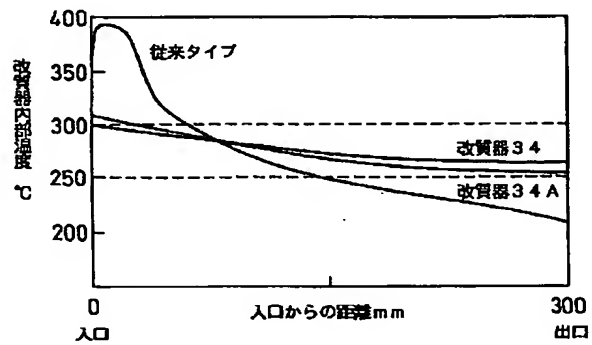
【図9】



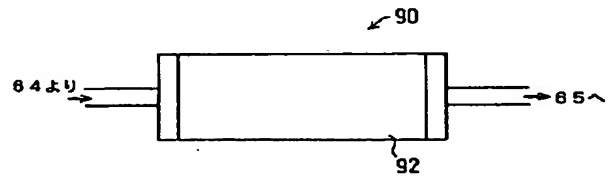
【図2】



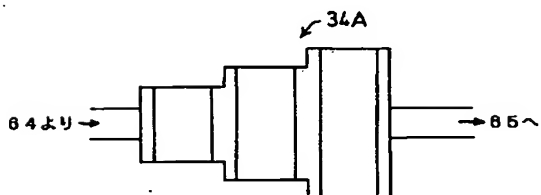
【図5】



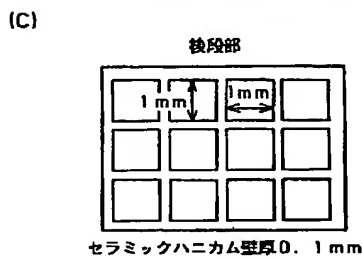
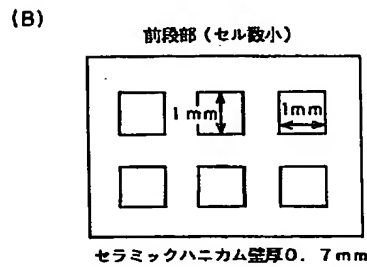
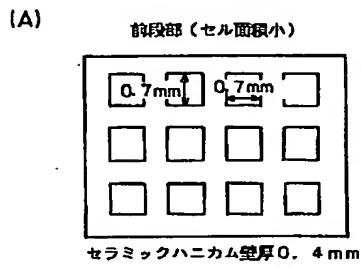
【図8】



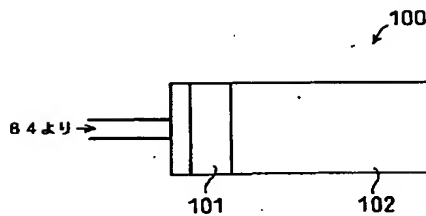
【図7】



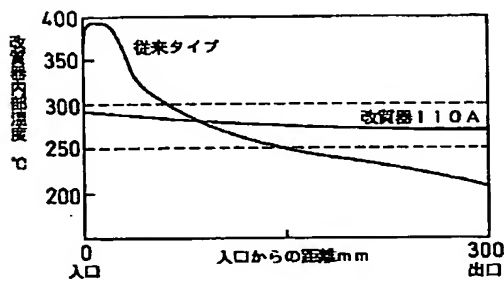
【図 6】



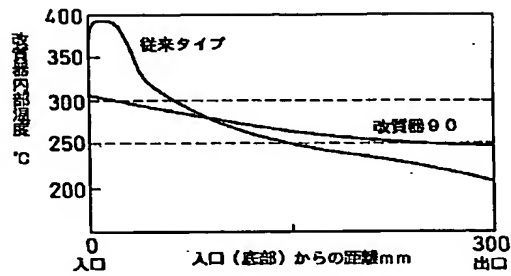
【図 11】



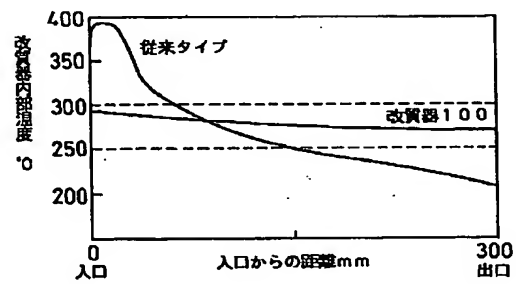
【図 16】



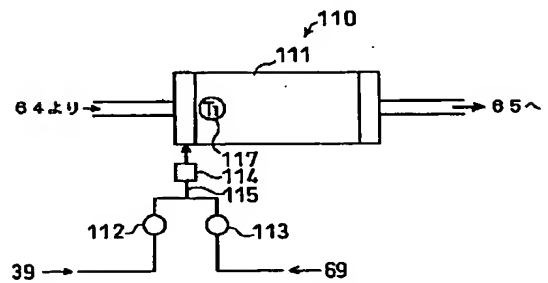
【図 10】



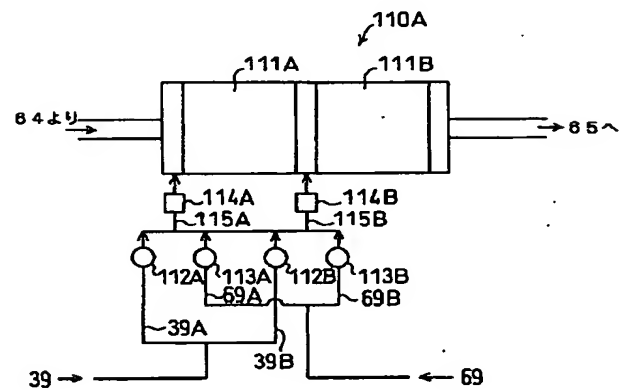
【図 12】



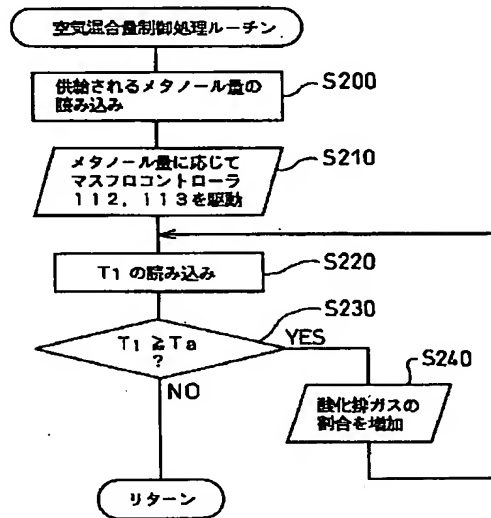
【図 13】



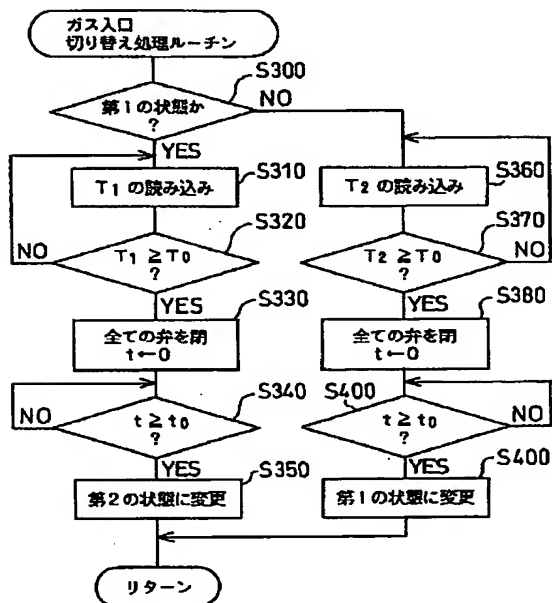
【図 15】



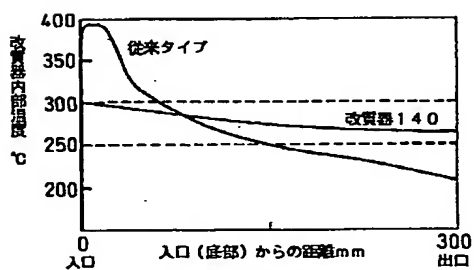
【図14】



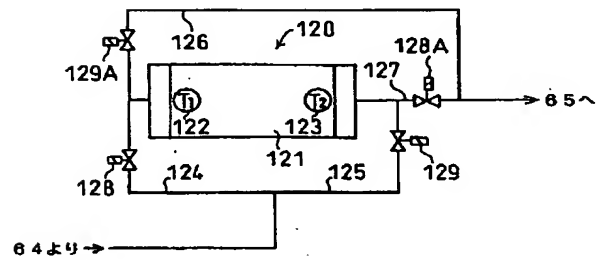
【図18】



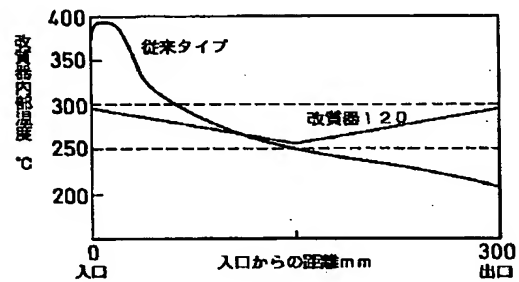
【図23】



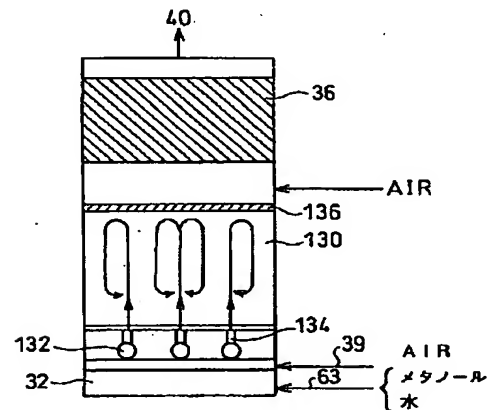
【図17】



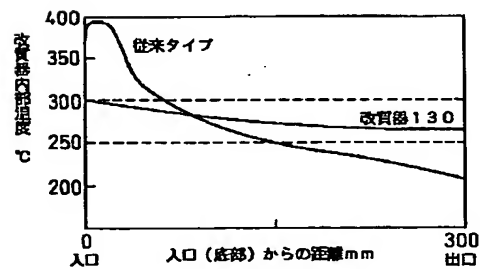
【図19】



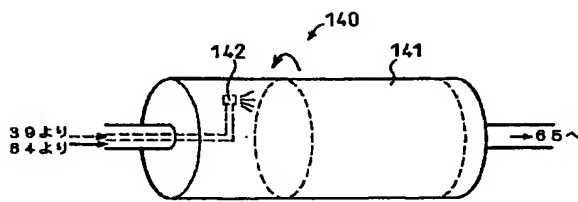
【図20】



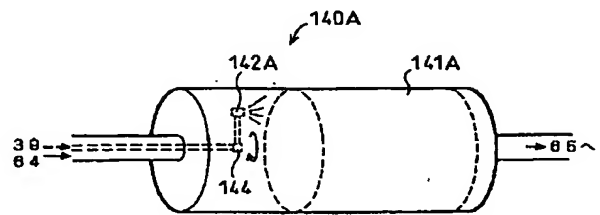
【図21】



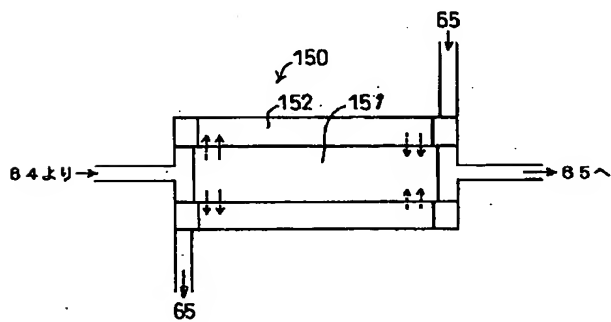
【図22】



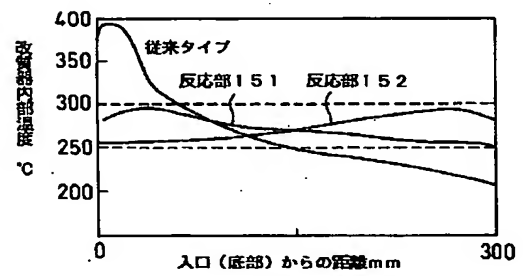
【図24】



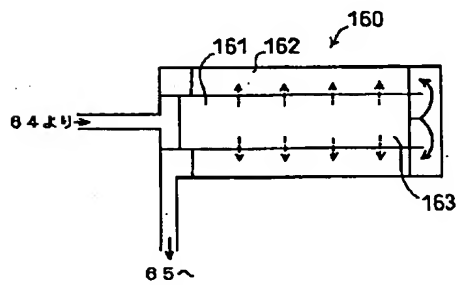
【図25】



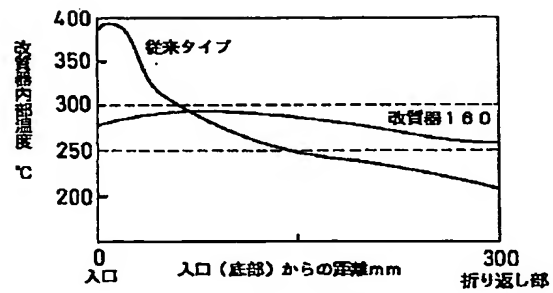
【図26】



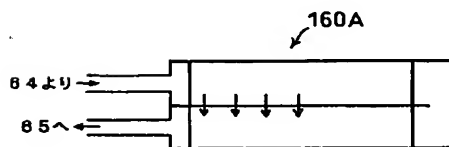
【図27】



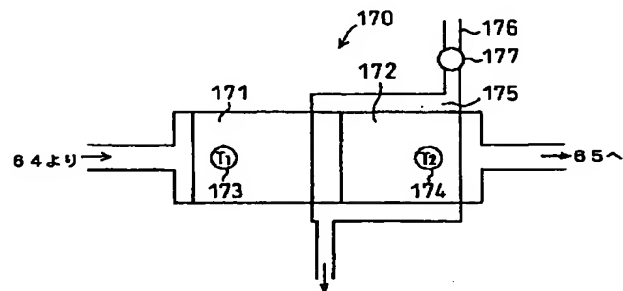
【図28】



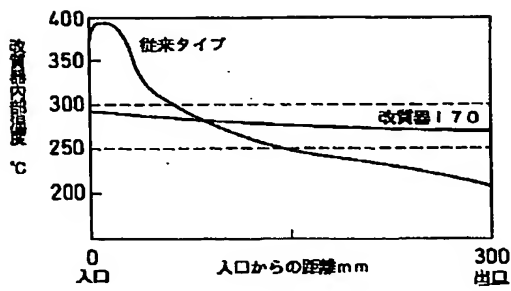
【図29】



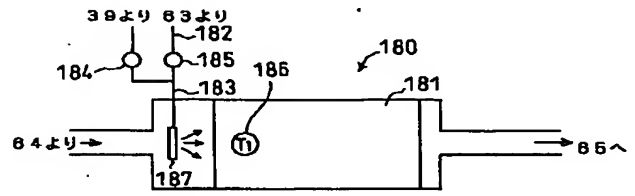
【図30】



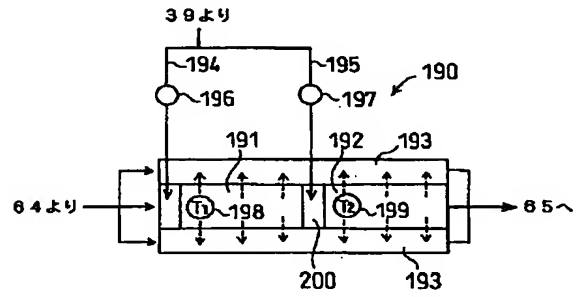
【図31】



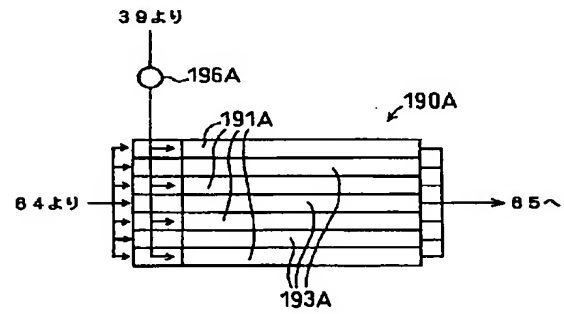
【図32】



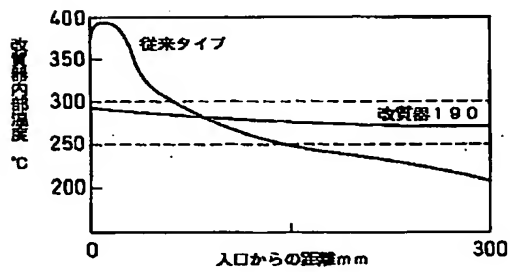
【図34】



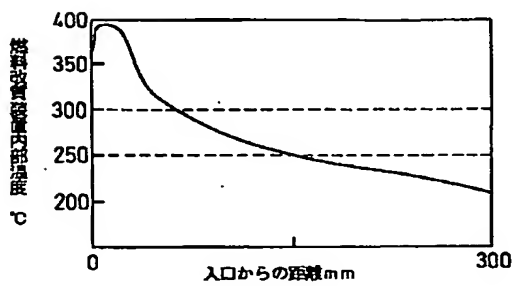
【図36】



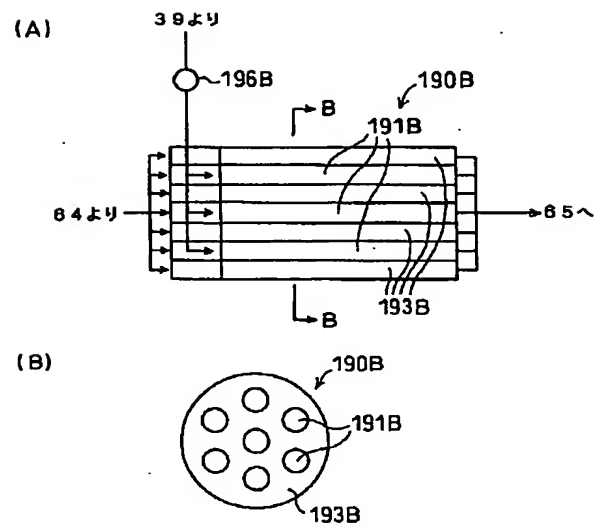
【図35】



【図38】



【図 37】



フロントページの続き

(72) 発明者 滝 正佳
愛知県豊田市トヨタ町1番地 トヨタ自動
車株式会社内

(72) 発明者 木下 克彦
愛知県豊田市トヨタ町1番地 トヨタ自動
車株式会社内

(72) 発明者 根岸 良昌
愛知県豊田市トヨタ町1番地 トヨタ自動
車株式会社内